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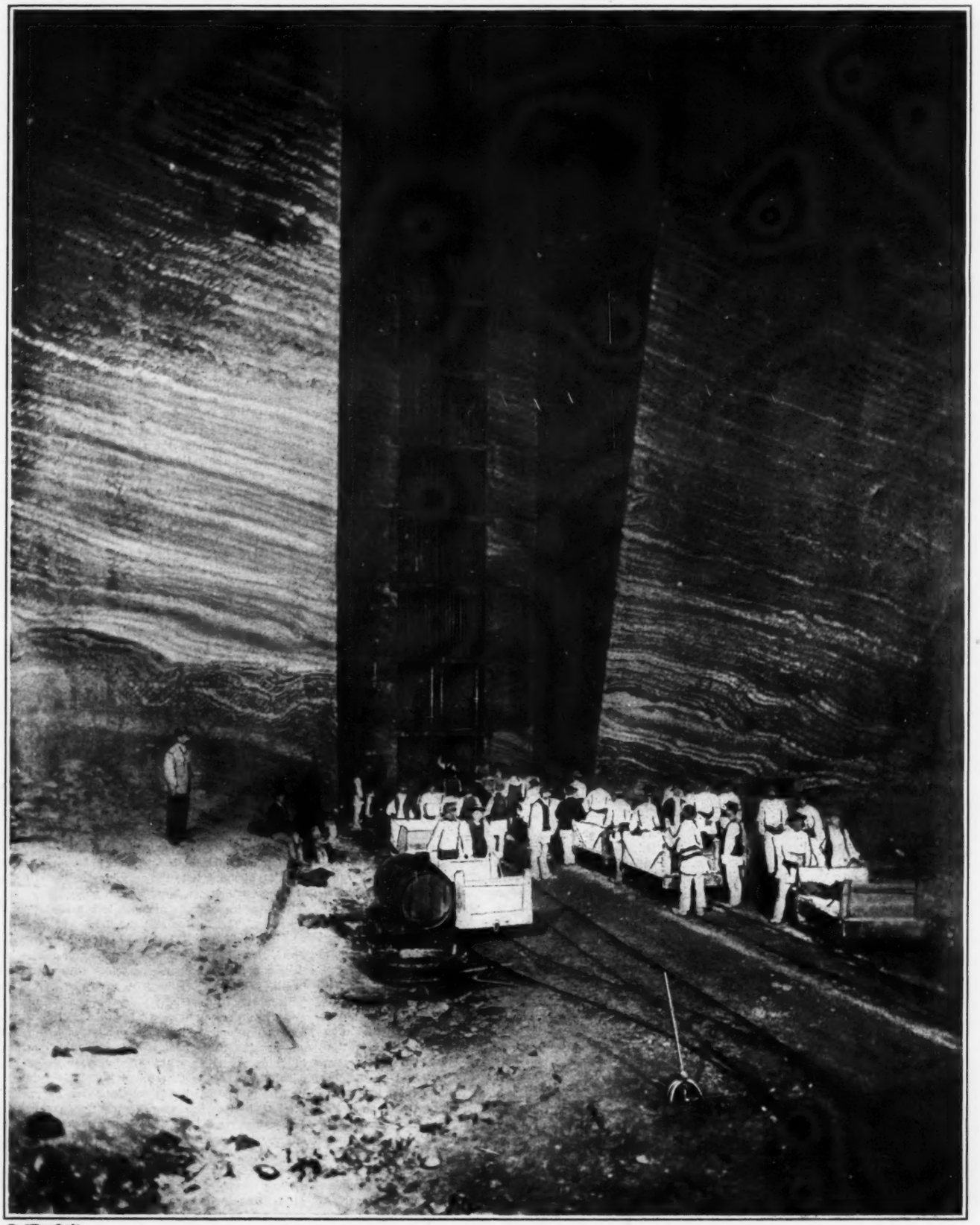


The Gillmore Service

One of Rumania's great salt mines, now being worked by the Germans for their own benefit

WHERE GERMANY IS OBTAINING INDISPENSABLE SUPPLIES [See page 276]

The Wars of Insects*

The Struggle For Existence Involves Every Living Creature

By F. L. Bouvier, Member of the Institute, Professor at the National Museum of Natural History, France

Words, like books, have a destiny of their own, and at times this destiny is frightfully tragic. When Charles Darwin formulated his hypothesis of natural selection through the struggle for existence, he was far from suspecting that a barbarous people would later make use of it as a justification for monstrous appetites. "The struggle for existence," he says, "is the inevitable consequence of the rapidity with which all living creatures tend to multiply": In the course of a complete career, each of them procreates itself many times, so that its descendents increase in a geometric ratio, and would eventually invade the entire world, if some regulating agent did not interfere to limit their number. This agent is the struggle for existence, which puts each individual in competition with its neighbors. Living organisms all pursue the same object; but this object is life, or rather the means of living, and that which some obtain is lacked by others; where the former are able to exist and to increase, the latter will have but a precarious existence, or will perish: survival is the lot of the best adapted.

This struggle is as inexorable as all the laws of nature; but, though not an hour passes that its victims are not counted by thousands, it would be a mistake to believe that this is the usual cause of battles and wars. Among the plants which grow on the same soil, and the carnivorous animals which hunt the herbivorous animals upon the same territory, the struggle differs only in its methods; each individual seeks solely to feed himself, and for that purpose makes use of all the means at his disposal; the plant uses its roots and its leaves; the beast of prey its claws and its teeth; but in the one case as in the other competitors have little thought of their neighbors and allow them to prosper or to perish according as they are more or less well adapted for the struggle.

Thus the struggle for existence is nothing more than vital competition, and this was the thought in the mind of Darwin, who almost always used the word competition, and only once designated this struggle by the name of war. Darwin observes, moreover, that he "employs the term struggle for existence in a large and metaphorical sense," applicable as well to the plant as to the animal, to the egg and to the young creature as to the adult; that is, to the most pacific creatures as well as to the most violent; but he belongs to those minds which understand how to impart to metaphor the direction of their ambitions. Subjected to the glosses of the German theoreticians, the formula of the biologist has become the *Kampf für dusein* (the combat for existence), the idea expressed by von Bernhardi in the words "War is the fundamental lot of nature;" and today we know only too well the significance which the Teutonic intelligence attributes to the terms, Combat and War! Thus distorted, Darwin's theory has spread throughout Germany; it appeared to justify the perverse instincts of an entire nation. Upon this they fed their soul, and it was this which has led us into the present cataclysm. Words do have a destiny of their own!

In reality, true war, that which brings into violent conflict hostile groups, must necessarily be an exception in nature, for it supposes certain solidarity between the combatants of each party, and it is a well-known fact that absolute individualism reigns among the majority of living creatures. Among the majority, but not among all; many animals, in fact, seek the companionship of their kind, and in company with them form individual societies in which each member works for his own benefit, or even at times more perfect societies, where each profits by the work of all, and all by the work of each—communistic societies.

But a condition of war appears in the defensive form in individual societies having superior instincts, in particular among the stinging Hymenoptera, which establish their burrows side by side: when isolated or living in small groups these insects allow themselves to be disturbed without retaliation; but when living in large communities they attack the aggressor in a belligerent swarm. I have put this to the test with the Bembex fly chasers; and the entomologist Friese reports that he was violently attacked when he drew a string along the walls of a barn where nearly ten thousand Anthophoridæ had dug their nests. These defensive sorties are an almost universal rule in the communistic societies of insects; especially in those where workers possess the poisonous sting. We know how tenacious the wasps are in their pursuits. Though devoted to flowers, the bees yield nothing in this respect to the wasps. Were they conscious of the fate which awaits them, we might even call them more heroic, for they leave their sting, together with its glands, in the flanks of the victim, and themselves perish shortly after this personal evisceration: "Terrible in their wrath when offended," sung Virgil, "they revenge themselves by the poison of their stings. They speed an arrow which pierces to the very blood, and within the wound they leave their dart and their life."

The warlike instinct of the communistic insects keeps step with their social evolution; it reduces itself to a mere defensive among the bumble bees and the wasps; *i. e.*, among the species in which the neutrals are hard to distinguish from the sexed individuals; it attains its highest development, on the contrary, in those colonies in which the neutrals are very distinct from the reproductive royalties, as is the case among the termites, the bees and the ants. Among these it is not rare to see the neutrals differentiated into workers and soldiers; the former devoted to labor and struggle, the latter to the defense of the colony. The soldiers of the *Eutermes*, or true termites, have weaker mandibles than do the workers, and leave to the latter the principal rôle in battle. To make amends for this, however, they possess a frontal horn, having a viscous secretion, and they utilize this weapon for the common defense. Among the black termites, studied by Bugnion, they enclose the long file of marching workers within a double hedge, standing with their heads turned outward ready to glue with their secretion the unhappy aggressor.

The beehive, considered an asylum of peaceful labor, is, in reality, the theatre of violent conflicts, more numerous and better known than those of the termites. When by accident two queens find themselves in the same hive, they plunge into a duel to the death, surrounded by the impassive workers, who await the death of one of the matrons to accept the other, for the republic cannot subsist with several egg-layers. Later, after the swarming has taken place, comes the massacre of the now useless males. "Then," says Maeterlinck, "the amicable perfume of nectar gives place to the bitter odor of those drops of poison clinging at the end of the stings and spreads rancor and hate." Deprived of arms and accustomed to idleness, the unhappy males are incapable of defending themselves against the pack of workers. Some of them succumb to stings, the others blockaded in a corner or chased from the hive, perish of want," and the memory of the idle race is extinct until the following spring. These are intestine struggles necessary to the normal development of the society. The case is not the same when threatened famine, joined with excess of population, drives the bee to covet the booty of neighboring hives. This is in spring or autumn, when flowers are rare, and the scouting workers readily become robbers. When they find an orphan hive, or succeed in penetrating into an enfeebled one, a sudden warlike tumult is roused among the populace when they go back home; an attack is decided upon, the assailing troops follow each other in tumultuous flights; they seek to force the place, and are sternly received by the besieged; it is a struggle to the death, and the air is filled with raging swarms. In the fury which is aroused, the combat may extend to neighboring colonies, and even invade the entire apiary. If the place is taken, "the victors," says Bonnier, "rob and kill remorselessly, carrying away provisions of honey, etc., as at random, massacring the last defenders, seeking the queen especially, in order to kill her, and even putting to death the young bees not yet developed, extracting them from their cradles. Here we have the most frightful spectacle imaginable, the true war of frightfulness."

Like the bees, the ants in a community recognize each other by touch and odor, treating as enemies individuals from another nest; and the more numerous their comrades are, the more courageous do they show themselves. Thus endowed by nature they can give free reign to their bellicose instincts, and scarcely restrain them. They do not lack subjects of conflict. They are very jealous of the territory they exploit and give battle upon the least infringement of neighboring societies; and though the majority of them are omnivorous, we see them enter into conflict in order to capture the eggs, larvæ and nymphs of other ant hills, but they particularly enjoy this delicate ant-brood. It is not impossible that some of the captured nymphs attain majority before being eaten; in this case the robber society contains young ants which have the same odor as the original members of the nest, and which will be adopted as fellow-members and workers. Such may be, according to Darwin, the origin of slavery among ants; and this seems to have been the opinion also of Pierre Huber, who discovered this curious phenomenon in 1810; however, we know of no other species which exactly follows this method; nearly always slavery results from the inaptitude of queens in founding a nest, an inaptitude which obliges them to seek admission in a stronger colony, most usually an orphan colony, where their progeny is reared, and later devotes itself to the pillage of other colonies of the same species, which occasions battle. It is customary to designate by the name of slaves the workers issuing from captured eggs; but these are, in fact, not slaves but auxiliaries, who work freely and form a mixed colony with their possessors. Thus relieved of normal duties, the slave-holding ants undergo profound modifications. The Sanguine Ant is not yet totally dependent upon the Ash-Black Ant and the Burrowing Ant, which serve it as slaves; it is capable of feeding itself and is able to live alone when it forms populous societies. The Amazon captures the same species, and is not able to get along without them; incapable of taking food except from their lips. It has scythe-like mandibles and is capable only of combat and capture.

Retrogression, produced by slavery, is still more accentuated in the *Anergates Atratulus*, which forms communities with the worker members of the Turf Ant. Having these workers at its disposal, this species does not produce workers, so that its colonies are reduced to one obese female and a certain number of veriform males, both of them almost entirely lacking in buccal apparatus. The master has lived too much at the expense of his victims; by a reaction which is not without example in human history, he has become the slave of his slaves! All ants are not equally bellicose, though all possess poison glands and mandibles, and sometimes a sting also; and all do not make use of their weapons equally. What a difference between our irascible Red Ant, which instills a smarting poison with its elongated sting, and the *Messor* or Harvest Ants, timid though strong, because they are armed with a very short sting. Among the non-stinging species the differences are not less accentuated; some utilize their mandibles; the *Camponotos* for biting, the *Lasius* to seize the enemy by the legs, the *Polyergus* or Amazons to perforate the skull; others make use of poison to such an extent as their anatomical structure permits. The *Formica*, or true ants, in the form of jets while holding onto a solid body; the *Tapinoma*, or gnawing ants, by applying it to the enemy by means of a flexible abdomen, which can be moved in every direction.

The tactics of ants are not less varied than their weapons. The *Lasius* and the Turf Ant excel in the war of barricades. When the *Lasius* are besieged, says Forel, they do not seek to fly, "but hide themselves in their subterranean chambers, which they defend to the death, gallery by gallery; they choke every avenue with grains of earth, which the enemy must move away in order to advance." Sometimes this turns into a chronic combat, like the combat which constantly engages the tiny *Solenopsis Fugax*, which establishes its minute tunnels within the very walls of another ant hill, and finds therein an inviolable refuge when it has plundered its booty from its big neighbors. Pitched battles are very frequent. In the simplest cases they consist of a frontal attack, in which the adversaries dispute the field of battle foot by foot. Huber describes a combat of this sort between two colonies of Tawny ants: "Imagine," he says, "a prodigious crowd of these insects filling the whole space (100 paces) which separated the two ant hills, and occupying a width of two feet. The two armies met half way between their respective habitations. The field of battle covered two or three square feet; a pene-

*An address made at the Plenary Reunion of the Five Academies of the Institute, October, 1917. From *Revue Scientifique*.

trating odor was everywhere exhaled; a number of ants were seen dead and covered with poison; others, forming groups and chains, were hooked together by their legs or mandibles and dragged each other alternately in different directions." Interrupted by dark, the combat was begun again the next day, and came to an end without a victory because checked by rain. Quite as strong, but more crafty, the Sanguine Ant sends to combat a succession of small numbers of troops, which seek the weak points of the enemy in order to make an attack on the rear or the flank. The Meadow Ants find it difficult to support these lateral maneuvers without panic. On the other hand, the Ash-Black Ant and the Burrowing Ant, the latter the same which provides slaves for the Sanguine Ants, defend their property jealously. It is a great sight to see them falling on the hostile vanguard, and posting defenders at every orifice of the nest; but the Sanguine Ants have meanwhile received reinforcements and surround the ant hill. They make an assault, penetrate the dome and stand guard over every opening, establishing, says Forel, "a veritable customhouse, which permits the ants to come out alone, but forces all those carrying nymphs to re-enter the nests." Immediately afterward they start in pursuit of fleeing ants in order to recapture from them what few nymphs they have been able to carry away. They then re-enter the conquered city and calmly move out the ant-brood. "It is a case of razzia," says Forel, "as complete as possible."

The same species respond differently to the attack of the Amazons. While the Ash-Black Ant offers but a slight resistance, the Burrowing Ant covers its dome with combatants, which fight with the skull perforators in an indescribable *mêlée;* even more when the army of Amazons returns to its nest with its booty of ant-brood. The emboldened Burrowers start in pursuit and engage in a new conflict with them to rescue their precious load. The ground is covered with new victims, and in these battles, as in all the wars of ants, one sees the wandering little *Tapinome* run hither and thither to take possession of corpses, or kill the dying. These armies have their guerillas, as human battalions have, and Pierre Huber's remark, "The wars of the anis can be compared only to those of men," seems to be justified even in this detail.

How shall we explain this strange resemblance? Without doubt, war is the result of social habitudes. Without doubt, also, it is a manifestation of the struggle for existence; but by what paths have these causes identical in the two cases been able to lead to the same effects? The common origin of the Arthropods and the Vertebrata is apparently too remote for there to be any question of hereditary ties between these divergent branches, and we must invoke the psychology belonging to each of these two warrior groups; but the psychological evolution of the animal proceeds by slight intellectual advances, which speedily become fixed into hereditary automatisms, while that of men proceeds by continuous operation of the intelligence, by strong power of invention, which relegates the effects of heredity to the background. "In the animal," says Bergson, "invention is never anything but variation upon the theme of routine. Confined within the habits of the species, it doubtless succeeds in broadening these by its individual initiative; but it escapes from automatism only for an instant, a time just long enough to create a new automatism. No sooner are the doors of its prison open than they close again, by dragging upon its chain it succeeds only in lengthening it. In the case of men the chain is broken by conscious action." Thus the wars of insects and the wars of mankind are the result of diametrically different social evolutions, but they proceed from the same causes, and it is probably by necessity that they have taken the same form.

Before leaving Pierre Huber, let us examine the melancholy question he presents in the course of his researches upon ants: "Is it true that the scourge of war is inseparable from the state of society?"

Admitting that war made its appearance together with the social state, and that it develops with it; admitting furthermore that it is a form of the struggle for existence, there is reason to believe that it will last as long as do societies of animals. But we have not the right to extend this conclusion to human societies. Without doubt, man is an animal in his organic structure. He goes beyond animality by the power of his mind; and we cannot doubt that he is subject, like all creatures, to the inflexible rules of the struggle for existence. It is none the less certain that he brings to this struggle new elements born of his own spirituality. When these elements are the search for and the defense of an ideal, of kindness, of justice and of liberty, they constitute powerful forces which add themselves to material forces to assure the triumph of the right. And since, in the struggle for existence, success belongs to the fittest—that is to say, to him who brings into play the greater number of forces—it would appear that the forces of a high ideal would contribute to triumph in human conflicts. In reality they have hardly done this up to the present time because they have been in a state of incompleteness, but they are dominating features in the cataclysm which is at this moment overwhelming the world, and everyone sees already that they will be one of the principal factors in victory. They will be tenfold as strong as brutal forces and assure the triumph of the right.

Will a day come when they will be sufficient to decide this triumph? Possibly so, for human societies, like animal societies, are in process of evolution; and in spite of the refined atrocity of this horrible war, it is apparent that in the majority of nations normal evolution is taking place in the direction of justice; but it is still more obvious that not all nations have arrived at this stage; and that for certain ones among them brute force remains the creator of right. If truly these peoples are capable of advancing towards another ideal, their transformation will be a matter of time, for they will evolve, like all other creatures, either by slow transformation or suddenly by mutation, and mutation is merely the sudden release of a long evolution. Are our adversaries near the evolutionary point at which consciousness will refuse to base right upon anything other than moral forces? It is not very probable. Therefore, in waiting for this evolution to be accomplished, if it be possible, it would be wise to remember the Roman motto: "*Cavcant Consules,*" and to lend to the moral forces the aid of material forces to assure maintenance of the right.

The Dead Sea Not Dead

"To most people who can combine into one the romance of history, science, and beauty, the Jordan valley must ever remain a region apart—unique," declared Dr. E. W. G. Masterman, addressing the Royal Geographical Society.

A tradition due to the New Testament narrators, and even more to mediæval painters, had associated the Lake of Galilee with violent and dangerous tempests. Although sudden and unexpected squalls, often localized, frequently occurred, through winds blowing from the highlands down some of the valleys debouching on the lake, storms dangerous to anything but small fishing boats were rare.

The extraordinary saltness of the Dead Sea had been ascribed to three causes:—(1) That its waters were once connected with the ocean, and that this water—salt at the time—has been concentrated by evaporation. This (said Dr. Masterman) is very doubtful. (2) That the salts are derived from the erosion of rock, and the concentration of the vast amount of water impregnated with soluble salts in this way by the enormous evaporation that has been going on for untold ages; and (3) that the atmospheric transportation of salt from the Mediterranean has been a very important contributing factor, if not the chief one.

Salt was a monopoly of the Turkish Government, and armed guards were kept during the summer to prevent smuggling, but were withdrawn in winter, and smuggling occurred with little attempt at secrecy. The Arabs plunged into the lagoons and brought up the masses of salt from the bottom with their hands, often having to submerge their heads as well as their arms.

THE ABUNDANCE OF ASPHALT

Asphalt was also claimed by the Government. Small fragments could be found almost everywhere along the beach, but not infrequently the Arabs found masses of several pounds' weight, and at times—especially it was said after earthquake—huge masses, large enough to support the weight of a great number of human beings had appeared floating on the sea. It had not yet been definitely ascertained where these deposits lay, and hitherto the Sultan of Turkey had discouraged all attempts to explore scientifically the deposits. It was quite possible petroleum deposits might yet be found in this most interesting region. Travelers by boat along the eastern shores had reported the occurrence of petroleum upon the surface of the water in places.

Until recently the Dead Sea had no boats on it. Some years ago the Greek Patriarch, at great trouble and expense, had a small steamboat conveyed from Jaffa and launched on the Lower Jordan to take excursions on the lake. One trip was made, to which many Consuls were invited, and then orders came from Constantinople that permission to navigate the Dead Sea was refused. We now learn that there are a number of boats, including at least one motor-boat, brought from Jaffa, engaged on the transport of guns and munitions of war from the East across the Dead Sea for the use of the Turkish Army.

Dr. Masterman asserted that there was an accumulation of indisputable facts showing that there had been a considerable rise in the level of the Dead Sea during the nineteenth century—a rise which had been accompanied—as he firmly believed—by a steadily increasing rainfall. The amount of sediment brought down by the muddy Jordan was enormous, and one geologist calculated that the Jordan delta had within the historic period encroached upon the sea to an extent of fifteen to twenty square miles.

REMARKABLE PHENOMENA OF THE WATERS

Travellers in past years had reported a curious "white line" which was visible at times running north and south down the center of the sea, and many speculations were made as to its cause, one divinity professor even suggesting that it might represent some existing rift in the bottom of the sea. This line (said the speaker) was due to an elongated mass of compacted foam which, on account of the dense and oily character of the Dead Sea water, remained floating on the surface longer than such foam would remain on the ocean. During east winds it was blown steadily across the lake in a long irregular line. There was also a peculiar disturbance of the water. An American traveller had reported that on three successive nights, when no wind was stirring, a heavy breaker came pounding upon the beach, followed by a succession of other waves for about an hour. Dr. Masterman reported a similar experience, and attributed the wave disturbance to the rapid change of temperature which sets in shortly after sunset.

PLANT AND ANIMAL LIFE

Ancient writers established a myth that the Dead Sea was an abode of death, that its shores were sterile, and that even birds flying over its waters were liable to fall dead. All these ideas were now known to be the reverse of the truth. It was true that the waters were so permeated with salt that no animal or vegetable life could flourish in the bulk of its volume, but near the shores, where streams of brackish water found their way into the sea, small fish, crabs, and mosquito larvæ were found, and he had seen fish in the sea. A bottle of water taken from the same spot immediately afterwards was proved to contain no less than 33.3 per cent. of solids. In one of the Jericho hotels, before the war, there was a declaration jointly signed the same year by over a dozen tourists that they saw fish actively swimming at the same spot. At many spots along the shore there are cases in which acres of reeds and many trees flourished, and at such spots animal life and bird life was abundant.

Without the great Jordan rift the whole history of mankind might well have been very different. Perhaps the Dead Sea itself and its lofty mountains were the most beautiful of all things in the land. The visitor looked for sterility and death and found a lake of ever-changing colors and varied movements and plenty of life at many a point, set in the midst of majestic mountain chains where, if viewed from the lakeside, every valley stood out with a brilliant clearness.—From *The English Mechanic.*

New "Total-Immersion" Hydrometer

To a glass bulb, weighted with shot, and of about 25 cm. external volume, is attached a fine chain about 40 cm. long. The chain is made of doubly-gilded brass and contains about 500 links of equal weight. When the bulb and chain are put into a glass cylinder containing a liquid of such density that the bulb is totally immersed, the bulb will sink in the liquid and the chain will coil up on the bottom of the cylinder until a position of equilibrium is reached. The cylinder containing the liquid is so graduated that the density of the liquid in it can be determined from the position of the pointed upper end of the glass bulb. It is shown that the max. error in the density is less than the accuracy with which the divisions on the cylinder can be read, the average error not exceeding 0.02 per cent. If the bulb is made of quartz, the chain of gold, and a Dewar vacuum vessel is used to contain the liquid, an accuracy of about 0.002 per cent can be obtained. It is convenient to have a glass cylinder with a false bottom on which the chain coils up. The bottom of the cylinder is drawn out to a tube and fitted with rubber tubing and clip so that the liquid can be conveniently run out.—Note from *Science Abstracts* on a paper by A. ANGSTROM and H. PETTERSSON in *Zeits. Instrumentenk.*

Photo by the Gillams Service

The culture of grapes and the making of wine in Rumania has been entirely reorganized and greatly increased by the Germans since the beginning of the war, to their great advantage

Fuel for motor vehicles of all kinds, and for submarines is one of the most important problems of the war, and control of the oil fields of Rumania has been of immense value to the Central Powers

Where Germany Is Obtaining Indispensable Supples

In the early days of the war the Allies, confident in their control of the seas, were sure that by cutting off indispensable supplies they could force a breakdown of Germany's military operations, but with inexplicable blindness they entirely overlooked the weak point in the line that threatened to circumscribe the Central Powers.

This was the Servian frontier, the gateway to extensive and wonderfully rich regions that abounded in many of the materials which Germany most needed. These included grain and food of various kinds, cotton, copper and, perhaps most important of all, oil for fuel, without which supplies munitions and guns for the armies could not be moved, nor the operation of submarines made effective.

This vital frontier was carelessly left to the Servians to guard, a people never strong as a military nation, and exhausted by long struggles with her neighbors; and when their opposition broke down, as was quickly and easily accomplished, the vast resources of Servia, Roumania and Bulgaria were made available to the Germans, and, worst of all, an open road was established with hostile Turkey, equally as rich and swarming with good fighting men, who only needed munitions to become a serious menace in many important directions.

If all communication between Germany and Turkey had been permanently blocked, what munitions the latter country possessed would have been quickly exhausted, with the result that opposition to the Russian advance in Armenia would have broken down, and but few allied troops would have sufficed for any operations that might have been considered necessary in Mesopotamia and Palestine, and the disastrous campaign of the Dardanelles would have had a far different ending.

Possibly the expedition to the Dardanelles was intended to remedy the original oversight, but, if so, it was a tardy and misdirected effort, of which the least said the better.

All of this has been recognized for some time, and freely admitted by Mr. Lloyd George in his great speech in Paris in November of last year, which shows how short-sighted even statesmen, who are supposed to be thoroughly informed on national conditions, may be.

Since the Germans broke down the wavering Servian line of defense they have been extremely busy exploiting the great territory opened to them, forcing the production of grain and other foodstuffs, the cultivation of the vineyards by modern methods, the mining of indispensable copper and other necessary minerals, and the growing of cotton, which is so much needed for the manufacture of explosives. Incidentally, the region is also being consolidated to form an important portion of that great central empire of which Germany dreams.

With the resources of this great district at her command, to which those of Russia will shortly be added, the starving of Germany, or the crippling of her supplies of munitions materials, seems impossible, at least in the near future, unless the enormous demands of her armies surpass even these important additions.

Scientific French, as it is Written

It has often been said that the French language is the most expressive in the world, and that it enables one to convey the most delicate shades of meaning with extreme accuracy. This may be true in the case of polite literature, but when it comes to technical or scientific matters it appears entirely inadequate to convey a definite meaning as clearly and as accurately as the subject-matter demands.

That this is no idle criticism is demonstrated by the recent publication in the *Comptes rendus* of the Paris Academy of a note entitled, "Observations sur le langage scientifique moderne," which severely criticises the French of some recent scientific papers, and gives

Rumania, Bulgaria and Servia are immense grain producing countries. The opening of the Black Sea has helped the German food supplies wonderfully

examples of badly constructed or unnecessary new words, the incorrect use of recognized words and of new technical words left undefined; and this note is signed by twenty well-known French scientific men.

It has always been the habit of French scientists to endeavor to give to their papers the semblance of an elegant literary character by the use of sonorous sentences that are rounded out by the use of an unnecessary number of recklessly selected adjectives and trivial parenthetical clauses, but when in addition they resort to the use of technical words to which they have appended arbitrary endings of their own invention, evidently with the intention of, in some way, modifying the ordinary meaning of the word, the reader is thrown into a sea of darkness and doubt.

It is these acknowledged anomalies of modern French scientific writing that has necessarily resulted in some peculiarities in the translations of various papers that have appeared in The Scientific American Supplement from time to time, but it should be understood that, wherever a doubt has arisen as to the meaning of a term, specialists in the subject treated of have been consulted, and the best rendering that it has been possible to obtain has been given; and in many cases a very literal translation of a paragraph has been presented in an endeavor to convey the author's meaning.

The Physical Power of Women

The mobilization of industrial power has involved the introduction of thousands of women to industry from what hitherto has been regarded as comparatively unproductive occupations in the home. The protection of women in industry is a matter of serious consideration, and regulations have been suggested whereby the standards of employment and the condition of environment shall safeguard their physical, mental, and moral welfare.

The weakness of women has been a favorite theme for numerous writers, and various men of scientific attainment have sought to prove the inferiority of women to men in every phase of development. When the facts and theories appeared to be contradictory, the facts were ignored and general credence was placed in the thought that generalization from special cases marked the lack of logic of those pretending to believe that the disabilities of the sexes were not due to sex itself.

The muscular strength of women has in general been assumed to be less than that of males, though for the most part the success of women in occupations requiring moderate expenditure of effort and continuous employment have failed to disclose the inability of women to cope with their male competitors.

Mosher and Martin, *Journal of American Medical Association*, January 19, 1918, report their studies of the muscular strength of the college women, as a result of which they conclude that sex is not necessarily a disability, but that some method must be found to adjust work to the individual strength under proper hygienic conditions. Under this circumstance, which incidentally should obtain in the employment of men, there is no reason to believe that the utilization of the potential power of women will in any way endanger their racial efficiency.

The constant protection of women, together with the limitations arising from their inadequate physical education and the restraint of their conventional attire, has resulted in an interference with their complete natural physical development. Certain variations in muscular power, such as, for example, those of the pectoral muscles, which are stronger in men than in women, may be explained by the vigorous character of exercise and play enjoyed by boyhood, but which is denied to girls because being a tomboy is deemed undesirable and because corsets, tight waists and dainty materials do not permit equal activity for the pectoral muscles during girlhood and young womanhood.

Some certain groups of muscles whose exercise is required for buttoning dresses up the back or putting up the hair, or for engaging in sewing, knitting and similar feminine occupations are more highly developed among women than among their brothers, and it would seeem to indicate that the factor of use has more determining qualities in developing power than the mere fact of being either a man or woman. The potential muscular power of women has not been developed nor has there been adequate consideration of the necessity of developing the strength, activity and physical power during girlhood.—*American Medicine.*

The Enclosed Observing Room*

By Russell W. Porter

SEVERAL successful attempts have given the astronomer a closed observing room, where he is independent of outside fluctuations of temperature. While in nearly every case the refracting telescope has been used, it is probable that with the increasing popularity of the reflector, efforts in the near future will be directed towards the adaptation of this latter form to the problem. It is, therefore, of interest at this time to gather together what has already been accomplished in this direction, and to point out the latent possibilities of the reflector.

In the accompanying diagrams, each arrangement of optical parts with its own peculiar form of mounting has been shorn of all accessories, in order to show only the principles involved. The optical parts are shown as in the meridian, which is the plane of the paper. There is no attempt at relative scale, and only such mountings as can give a motion around the polar axis have been considered. Their salient characteristics will first be compared.

In each of the types shown the usual optical parts of the telescope are supplemented by an auxiliary means for changing the direction of the axis of the light beam. For this purpose, in all excepting the Hartness Turret telescope one or more reflecting planes are used. The Hartness Turret uses a relatively small prism, and with the exception of this instrument, all the instruments have the eyepiece fixed so that the observer from any one position can cover the heavens only to the extent of the range of the instrument. The range of most of the instruments for this purpose exclude a small part of the circumpolar area and the sub-polar field. The Equatorial Coudé and the Hartness Turret are the only two instruments shown covering the whole heavens. The movement of the eyepiece in the Turret Equatorial ranges from horizontal east and west to looking downwards at the complement of the latitude. When used as a reflector, the direction and movement of the eyepiece remains the same.

The Sheepshanks telescope, No. III, brings the greater part of the heavens to the eye piece with one reflection. But its peculiarity is that the auxiliary mirror, situated at the intersection of the two axes, about midway between object glass and focus, travels (in declination) at half the angular rate of the glass itself.

The simplest form of all, and the one to be recommended to amateurs for its inexpensive mounting, is the Gerrish form, No. IV, used almost constantly in available weather at the Harvard Observatory. The reflection here is outside the object glass. It has been said that in adding a reflecting surface to an astronomical telescope, any imperfection in it will have less effect on the definition of the image the nearer it is placed to the focus. If so, then it would be an argument against large flats outside the objective and in favor of smaller mirrors placed inside—the nearer the eyepiece the better. Certainly, the smaller the mirror is made the less will be the weight, counterpoising, and expense.

There is one other form, not shown, where the refractor can be used, in which no reflection at all is required, and the entire heavens available, suggested by Professor Todd. The description has not yet been published, but the writer is familiar with the mounting, which is an extremely bold and ingenious one, where apparently all optical and mechanical details have been successfully worked out.

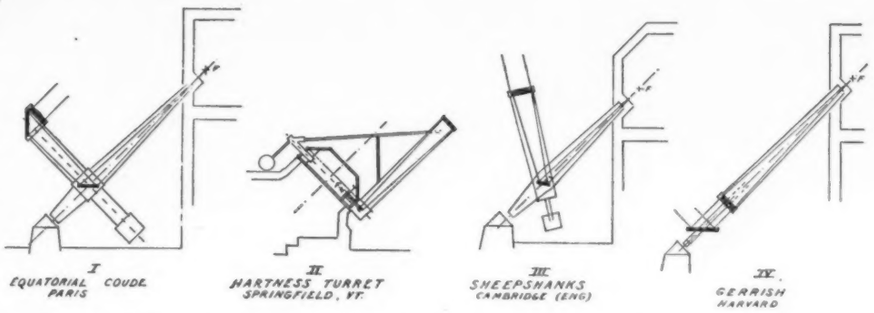
*From *Popular Astronomy.*

THE REFLECTOR

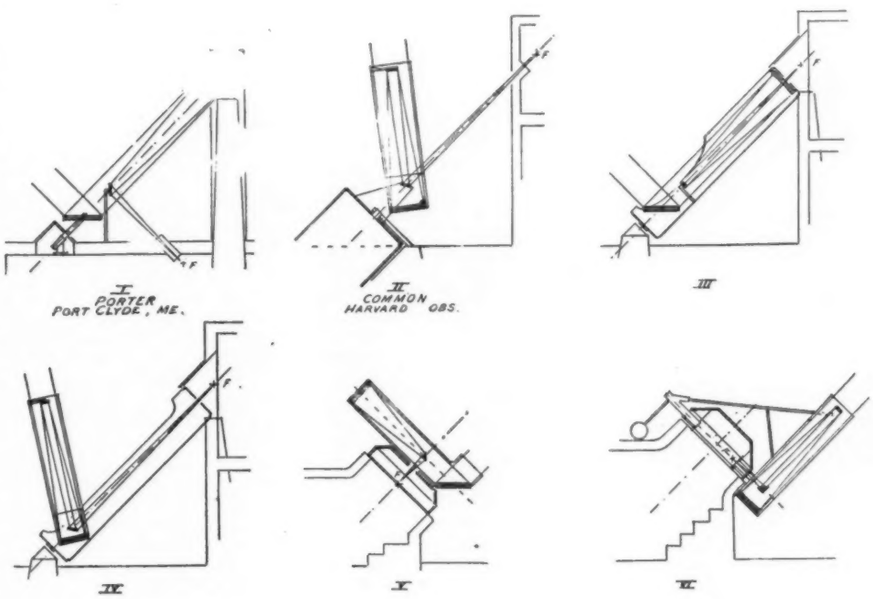
In the consideration of the reflector, we have to deal with an entirely different optical machine. The two forms—Newtonian and Cassegrainian—have normally one reflection each after leaving the parabolic mirror (which, let us say, takes the place of the object glass), in order to remove the observer's head from the optical axis.

To bring the eyepiece into the observing room seems to necessitate here, also, an additional reflection, whichever form is used, but the relative disposition of weights has been changed.

In the different forms here given (see Figure 2), but two have been tried, viz., No. I (by the writer), and No. II, which is the five foot Common at Harvard.



THE REFRACTING TELESCOPE ADAPTED TO A CLOSED OBSERVING ROOM.
Fig. 1.



THE REFLECTING TELESCOPE ADAPTED TO A CLOSED OBSERVING ROOM.
Fig. 2.

While found entirely practical for a closed observing room, No. I has the disadvantage of high supports, the inconvenience of looking up for protracted visual work or following, and a rigid eyepiece which does not revolve with the instrument. These objections would be met in No. III, by using the Cassegrainian form, and bringing all supports nearer the ground.

In the Common mounting, No. II, the Cassegrainian form is adapted to the principle found in the Sheepshanks refractor, where the additional reflecting surface travels in declination at half the angular rate of the primary. The eyepiece is however separate from the instrument mounting, and must have an independent motion imparted to it in right ascension for long exposures. The writer is now at work on another form of mounting, using the same principle, and shown in No. IV, where, it is hoped, troubles arising from flexure will be reduced. One of the mechanical problems in this form is to eliminate all tendency to slip, or back lash, in the small flat.

In No. V is indicated an arrangement which, so far as known to the writer, has never been tried, although suggested years ago by Brashear and Brooks. It is shown here adapted to the warmed observing room. It possesses the great advantage of mechanical stability and self counterpoising. It requires, however, a large flat, outside the parabolic mirror.

In No. VI is shown the Cassegrainian applied to the Hartness Turret mounting.

A warm, comfortable room, a relatively fixed eyepiece, an observer seated in a relaxed normal posture—these are the conditions sought for in the various attempts here described. It is generally recognized among astronomers that the quality of visual work is in direct proportion to the comfort of the observer. If this problem can be solved with the reflector, in bringing the eyepiece into the home by a simple inexpensive mounting, it will open the door to a number of amateurs who are now held back by the high cost of the refractor and its elaborate revolving dome, and the back-breaking attitudes to which he must now subject his body, in all kinds of temperature. It will be a great step towards popularizing the oldest and noblest of sciences, a science where the present day tendency of educational institutions is towards its becoming gradually shelved, in favor of other more pressing courses of study.

Malaria in Rumania

EVER since the time of Ovid, who laments the fevers so prevalent at Tomi (in the Dobrudsha), Rumania has been known to suffer severely from malaria, which overspreads the whole country with its great plains, reedy marshes, and slow rivers liable to widespread inundations. The region most heavily attacked is that between the Sereth and the Pruth, but no part of the country escapes. Sailors used to get higher pay for siling through the Dobrudsha, so great was the risk of fever, which occurred up in the mountains as well as along the water-courses. Babes reported in 1904 that in 7,000 post-mortem examinations he had rarely missed seeing evidence of malarial infection. Cases were as frequent in Rumania as they used to be in Italy, but the less deadly tertian fever was more common. The carrier anopheles are found everywhere. In 1899 it was attempted to dry up the marshes by planting there willows and poplars, but as the uncomprehending peasants delightedly burned the trees for fuel this experiment failed. In 1902 orders were given to embank the rivers to prevent floods and reduce malarial infection, but the good was too little clear, too speculative, and nothing material was achieved until in 1907 malaria prevention was linked to what people call a practical purpose, and the reclamation of areas liable to floods was undertaken in order to increase the arable acreage, a benefit riparian owners and occupiers could well understand. In 1904 Babes, with his colleagues Cantacuzenu, Sion, and Irimescu were appointed a committee to select some method of quinine prophylaxis and they chose Koch's system, which directs that 15 grains of quinine shall be given every ten days. Their report was adopted and the results were not long delayed: of 6,000 persons protected only 1 per cent fell sick; of 16,000 left untreated 18 per cent contracted marsh fever. Although only some 2 per cent of the population was reached by this prophylaxis, a great alteration in the situation had been achieved, and malarial fever cases were becoming rapidly fewer when, in 1913, the Bulgarian War distracted all the energies of the country and it began to fall back into its old state of a hundred years ago.—*The Lancet.*

Human Aids to Machines*

Man's Productive Capacity, Past and Present

By A. Russell Bond, Managing Editor Scientific American

RECENTLY one of my associates on the staff of THE SCIENTIFIC AMERICAN, Mr. J. M. Bird, undertook to investigate the productive capacity of man in the present day as compared to his capacity a hundred and fifty years ago—or before the age of machinery. He found the task a very complicated one, but he arrived at certain conclusions, from which I shall quote at some length, as they have a distinct bearing on the subject as announced in the program. His method of procedure was to investigate various occupations of former times, find out as best he could the quantity of product that a man could turn out in a given time, and compare this with the work of a man today who employs up-to-date machinery for the same class of product. He found that the type of machine containing the greatest labor-saving potentiality is the multiple unit one. "Here each unit replaces a single man worker, for the units are so combined that many of them are handled from a single control by a single operator. The units may work faster than the man, but this is an incident. The inherent advantage lies in the fact that here we have actual multiplication of the operative's hands. The example par excellence is the spinning wheel. Here one girl, in charge of several thousand spindles, will turn out from 10 to 12 thousand times as much cotton yarn as her great grandmother's mother could produce on the spinning wheel with its single spindle. In one type of mule the exact figures are 820,000 yards per hour, against 75. Knitting and weaving machines are not so effective, because they require more attention from the operator, who, accordingly, does not care for so many of them. Even so, the ordinary power loom increases the individual output of from 40 yards per week to well above 3,000—a factor of 75 or more."

In this way he went through the various types of multiple unit machines, not only in the textile industries, but in other lines of work as well, and finally arrived at the conclusion that from 75 to 100 seemed to represent a very fair general average for a productive factor of the multiple unit machine.

"The second fundamental type of machine is the one which requires an operative for each unit, and here the economy depends solely upon speeding up the work. It is in the book and magazine factory that we find the most consistent reliance placed in the single unit mechanism. The linotype, for instance, does the work of from four to eight hand compositors, and this is a fair average. On the old Ben Franklin press, requiring inking, insertion of paper, screwing down and screwing up again, and removal of the sheet, it was hardly possible to strike off more than 30 impressions per hour of four pages each. The latest flat-bed press has a practical capacity of 1,400 impressions per hour, and, printing 16 pages at each stroke, we get 22,400 pages per hour, against 120 by hand. Under union conditions, three men are required for two presses; so, in practice, we get a factor here of 120. But an automatic feeder is now on the market which makes it easily possible, as far as the machinery itself is concerned, for one man to run two presses. On this ground, without reference to extrinsic restrictions, it will be seen that the printing machinery is capable of multiplying the book printer's capacity by 360. In the bindery we find the gathering machine collecting the pages of five volumes while a girl is doing one. The case-making machine does a rather complicated job of cutting, fitting and pasting, and shows a factor of at least 10. The machine which puts the book in its jacket imitates closely the hand-worker's technic and attains a factor of somewhat less than 3."

Turning from this to other classes of work, we finally arrive at the figure 10 as a fair average factor for the single unit machine in all fields.

"There are other machines that so revolutionize the way of doing things that there can be no comparison with the hand-worker sufficiently close to justify either of the preceding classifications. One such type is that which receives the raw material in bulk and delivers the finished article—more often than not counted and packed. The web press for newspaper printing will turn huge cylinders of paper into finished news sheets at the rate of 288,000 eight-page papers per hour. Ten operatives are employed on the machine which gives us 230,400 pages per man per hour. This is something like 8,000 times as fast as Benjamin Franklin could have done the job." In the case of the web press the machine is really a factory in itself; on the other hand, we must consider many of our large factories as huge machines in which "the raw materials flow in a steady stream at one end and emerge at the shipping platform as the finished product. Automobiles, shoes, canned goods, etc., are some of the commodities whose mode of production is known to follow this plan." The only way to arrive at a comparison is "to divide the total output out of the factory by the number of employees and compare the output per man, thus found, with that of a single hand-worker. * * * When we make anything so complicated and heterogeneous as an internal combustion engine, or a pair of shoes, we inevitably find many operations that must be done by the slowest of machines or even by hand. When these form a governing factor in the output, we must either slow down the faster items to the pace of these slower ones or employ a disproportionate number of men at the slow jobs." Another complication is the fact that when a shoemaker makes a pair of shoes, "every second of his time spent in the work goes to the advancement of the job in hand, while in a big factory there may be hundreds of workers who never handle any part of the finished product. * * * Again, a shoemaker buys many small parts, such as eyelets, laces, etc., which, in a big factory, are worked up in the raw."

Considering all these complications, of which I have enumerated only a few, the conclusion is finally reached that the average factor of assembled goods would be about five.

Another class of machinery considered is that which affects economy "by taking a bigger bite of work than a man could handle. A good-sized bucket dredge, for instance, may multiply the efficiency of the worker by a hundred. The lifting and loading magnet moves 90 tons of metal per man per hour, against 1½ tons by a longshoreman in the old way. * * * The huge loading and unloading machines of the Great Lakes may replace almost any number of men from a hundred up; the bigger the job, the bigger the saving." For motor transportation 5 is the factor arrived at, while freight transportation by rail shows a factor of about 25.

The final conclusion from all these figures is that a man today is productively worth ten men of the period of 1750 to 1800.

Undoubtedly machinery has done wonders for man as a whole, but what I wish to consider in this paper is the relation between the machine and the man who operates the machine. The word "man" is used in the broad sense, including women, of course. When the primitive man first took up a stick of wood to defend himself against the beast, he was making use of a machine element; and this application of the lever certainly was an aid to the man. Gradually, very gradually at first, he began to develop other uses of this machine element and to acquire knowledge of other machine elements. Then he learned to combine them into machines that were increasingly useful. He began to use the powers of nature to drive the machine. The machine began to do the greater share of the work, until the relation between the man and the machine was reversed. The machine did the work with the help of the man.

Certainly a power-driven machine can hardly be classed as a mere aid to man; the man and machine do a certain work together, but they are not yoked together. The machine does the hauling and the man does the driving or directing. This is even true of many machines that are driven by human power. The machine actually does the work. It takes the energy furnished by the operator, multiplying it either in speed or in power, or otherwise utilizing it in a far more efficient way than a man could himself. And so we have certainly come to the age in which we can truthfully state that the machines are our workers and the operators are the directors of the machines.

I do not like the word "labor," as applied to the work of man in the industries. It always seems to indicate a great muscular effort and wearisome toil. While this may be true of many operations, we are rapidly advancing to the point in which the operator has less and less use for his muscles and more and more use for his brain. I think that the industrial engineer has a mission to perform in emphasizing this point for our industrial classes showing the operatives that machinery takes them out of the laboring class and makes them *directors* of machinery.

I should like to see the name "Labor Union" changed to "Director's Union." Please understand that I have not a word to say against the members of Labor Unions or their organization. They have dignified the word labor so that it has lost much of its original significance; and yet it did originally mean wearisome work and great muscular effort. But now we are gradually getting away from such toil and have entered a new era—an era in which brains count for more than muscle.

Man has developed marvellous mechanical contrivances. We have machines that can do almost anything that a man can do. We have machines that can see; machines that will keep watch of the smokestack of a steamer, and, if dense smoke comes out of the stack, will notify the engineer below, so that he can attend to the proper firing of his furnace. There are machines that can hear—that can take down a speech and record it on a wax cylinder, and which can then reproduce this speech exactly as it was given to them; machines that listen for the throbbing of the submarine's engines; railroad signals that respond to the blast of a locomotive whistle. There are machines that can feel the weight of a fly's wing; machines that can sense the tremble of the earth, five thousand miles away; machines that respond to the heat of celestial bodies trillions of miles distant; machines that can count the very atoms in the lightest of gases. On the other hand, we have machines that can lift stupendous masses of metal with little apparent effort; that can pick up a loaded coal car and pour out its contents; that can exert a pressure of ten million pounds on a test column.

All the senses of man have their counterpart in machines except possibly those of taste and smell, which are really chemical reactions; as I am using the term "machine" in the broadest sense I am not at all sure that there may not be certain instruments which will respond to the acidity or non-acidity of various solutions or to other chemical reactions that correspond to taste in the human machine. There is a mechanical contrivance which, if attached to the gas jet, will smell the gas when it has been blown out by Mr. John Hayseed, and bring into operation a mechanism that will light the gas again. There are machines that seem almost possessed with human intelligence. One clever inventor recently produced a mechanism that could remember and forget, although he never put the apparatus to any practical application. His purpose was merely to show that memory could be reproduced mechanically. This machine, if subjected to a certain reaction, would respond to that reaction for an hour, or for a day, or for any length of time to which it was adjusted, after which it would forget what it was supposed to do, and do the wrong thing, or fail to function altogether. More human in character, certainly of more service, are the machines which will solve mathematical problems. Not only those which will add and subtract, multiply and divide, but the complicated machines which will solve problems in calculus and higher mathematics—the integrator, for instance, which will solve problems that cannot be worked out mathematically. The tide recorder in Washington will perform mathematical calculations that a hundred computors could work out in the same time.

But wonderful as all these machines are, not one of them is endowed with real intelligence. Man can produce a machine that will play chess, but the machine cannot do its own thinking; it will only do what it has been designed to do. It will react to the various conditions to which it may be subjected, but it has no will of its own and no power of thought. No matter how far we may advance in the development of machinery we shall always come up against this barrier—the impossibility of producing brains. The most perfect of machines is useless without an intelligent operator. In the industries of the future, no matter how far they are advanced, operators will be indis-

*A paper delivered before the Society of Industrial Engineers at Chicago, March 28, 1918.

pensable; they will be required for their directive intelligence rather than their muscular power. Instead, therefore, of bewailing the fact, as men frequently do even in these enlightened days, that machines are replacing men we must look upon the subject from a broader point of view and realize that machines are demanding men, and that they are elevating man to a higher plane.

One of the sad features of the dreadful war we are now engaged in will be the return from the fighting front of men who have been disabled or crippled, so that they will be unfit for the work that they used to perform. This is a subject that is to be taken up at length tomorrow afternoon and evening; and while I do not wish to anticipate anything that may be said at that time, I wish to bring out a point which has a direct bearing upon the subject before us now. It is indeed fortunate that so many of our machines have developed to such a point that they do practically all of the work and the operator merely directs them. Were such not the case, the future of the crippled soldier would be sad indeed; but on his return from the front he will find plenty of opportunity for usefulness as a machine director—I like the word "director" even better than operative. No man will be so badly crippled, provided his power of thought is not impaired, that he cannot find a useful niche somewhere. In former times the war cripple was a liability upon the community—today the machine has turned him into an asset.

This, then, is the point I wish to stress. Machines are an aid to man; but they are our slaves, and they will not work without our direction. It is the duty of the industrial engineer to inspire machine directors with the dignity of their job; to make them receptive to further development of automatic machinery; to show the girl at the spinning mule, for instance, that she is an indispensable element, that she is the directing brain of a myriad-armed creature.

If the average productive capacity of a man today is ten times that of the man of yesterday it should grow tomorrow to twenty, to fifty, to a hundred. And the larger the productive factor becomes the higher will man ascend until he becomes the very soul of the machine.

The Energy Required to Produce Rain*

By J. Patterson

METEOROLOGY and geology, in their broader aspects, treat of the two fundamental subjects that make life possible on the globe. While the soil may make life impossible in certain regions, it is a fact that in most cases the necessary character of the soil to support life is almost entirely conditioned on the climate, and it is chiefly the climate that determines the character of the life in any region. This, then, is a most important subject for investigation.

Meteorology, as a science, is very young, perhaps some would say that it has not yet arrived at the stage when it can be called an exact science, but it is progressing. As a branch of human knowledge, however, it is probably the oldest in the world, going back to the advent of man in the world. Primitive man was chiefly engaged in agriculture and hunting, and, as such, would soon become familiar with the broader features of the climate, and, as an observer of Nature, he would be an observer of the weather, in order to protect himself against it or profit by it, rather than with any desire or thought as to the causes of the various kinds of weather that he experienced. In course of time he soon acquired considerable local weather knowledge, and this, in turn, became crystallized into proverbs which had all the finality of absoluteness about them. With the rise of the priestly caste, the weather was linked on to the constellations, and human and weather astrology went hand in hand. In fact, in Babylonian culture astrometeorology formed part of their religion. This is the source of much of the popular weather wisdom that still survives, and it is applied independent of the locality to which it originally referred. Now, belief in astrology in our country has practically died out as far as it refers to human beings, but it is not so in regard to weather astrology, for all long-range forecasting that depends on the stars is simply astrology. It is one of the characteristics of human nature that the superstitions and weather proverbs learned in childhood survive through most of one's adult life. One other peculiar feature of human nature is the regard in which these so-called prophets are held. When they have attained a certain notoriety they are considered infallible, apparently because only the chance successful guesses are remembered and the rest are forgotten. The weather proverbs and much of the forecasting by stars arose in an age when all phenomena were a mystery and in many cases produced by a god of good or evil repute. That this nonsense should still survive is, no doubt, due to the fact that, to the great mass of the people, the weather phenomena are still a mystery. We are highly amused at the absurd stories of primitive people in regard to the creation, etc.; but, considering their primitive character, should we consider these stories any more absurd than the weather proverbs and similar nonsense among people of the intelligence of those of our own country? It does point to this, that meteorology is almost entirely neglected throughout the whole of our educational system from the kindergarten to the university. This should not be so, but it is beyond my subject for this evening. I want you to look at this from another viewpoint.

It can best be illustrated by an example. Suppose you were given the task of sprinkling an acre with water to the depth of one inch. How much work would you do? Suppose the source of the water was right at the center of the field and that the field was circular of radius r feet. If you carried 6¼ gallons, or 1 cubic ft., each time, a simple calculation shows that you would have to travel nearly 110 miles to do it.

1 acre=43,560 sq. ft.

r= 1 7.7 ft.

Average distance of travel=2/3 $r\times2$=156 ft.

Number of cubic feet of water 43,560/12=3630.

$$\text{Distance travelled}=\frac{3{,}630\times156}{5{,}280}=110 \text{ miles.}$$

By the time you had finished you would feel, in fact you would be absolutely certain, that you had performed a great deal of work; whether useful or not is another question. Now when Nature starts her sprinkling can or turns on her hose, as she does at times, does she have to perform any work before she can do this or does she just do it without the expenditure of any energy? Let us see.

We all know that the moisture of the air is maintained by evaporation, and consequently all the moisture that is taken out of the air as rain was originally evaporated from the water on the earth's surface.

We also know that it requires heat to evaporate water, and experiment has shown that it requires as much heat to evaporate 1 lb. of water as it would require to heat 1,080 lbs. one degree. That being so, we find that it would take to evaporate 3,630 cubic ft. of water.

$$3{,}630\times\frac{125}{2}\times1{,}080 \text{ B.T.U.}$$

or expressed in work—

$$=3{,}630\times\frac{125}{2}\times1{,}080\times\frac{778}{33{,}000}$$

=5,764,000 H.P. per min.=96,000 H.P. per hour, or 4,000 H.P. per day.

This shows then that it would require a 96,000 H.P. engine working for one hour or a 4,000 H.P. engine for a whole day, transforming all its energy into the work of evaporation, to produce the vapor for one inch of rain on an acre. After the water has been evaporated it has to be raised to the level of the clouds about 4,500 ft. or 1,500 meters. The amount of work to do this is

$$3{,}630\times\frac{125}{2}\times\frac{4{,}500}{33{,}000}$$

=30,960 H.P. a min. or about=516 H.P. an hour, or 21.5 H.P. per day.

The total amount of work required to get sufficient water to the level of the clouds to give one inch of rain on an acre is thus 5,764,000+30,960 or 5,794,960 H.P. That is truly a stupendous amount of work to give 1 inch of rain per acre, and now the question arises, can we find any source of energy that is capable of giving so much power year in and year out? In considering this problem, however, we do not need to consider an area of one acre, but we can take 1 sq. cm. (.16 sq. in.) instead. Again let us take the precipitation for a year. In Toronto the average precipitation is about 34 in. per year, and while 40 in. is much above the average precipitation for the whole year, we can for convenience consider an average precipitation of 40 in. or 100 cm. over the whole world.

A depth of 100 cm. of rain on a sq. cm. surface would give 100 grammes of water per sq. cm. The amount of heat required to evaporate this is $100\times1{,}600$, or 60,000 calories per year, or on an average 166⅔ calories per day; but as the globe is made up of ¼ land and ¾ water and we consider the evaporation taking place from the water surface only, it would require 220 calories per sq. cm. per day of heat to evaporate sufficient water to give an average rainfall of 40 in. per year over the entire land and water surface of the globe. Where then can we find this amount of heat?

At Toronto, or on latitude 45° approximately, the daily average for the year is 256. The heat received per sq. cm. on a horizontal surface at latitude 45° would be approximately the average for the globe per sq. cm. There is thus more than enough heat received from the sun to evaporate sufficient water to give an annual precipitation over the world of 40 ins.; the average precipitation is certainly much less than this. You see, then, that as far as evaporation is concerned, the heat from the sun on the water surface is sufficient to evaporate all the water that is required for rainfall and still leave a considerable margin. Next, in regard to the energy required to lift the water to the level of the cloud, or 1,500 meters. To lift 1 gramme it will require an amount of energy equal to $1{,}500\times100\times1{,}000$ (approx.)$=15\times10^5$ ergs, or expressed in heat units=

$$=\frac{15\times10^5}{4.2\times10^7}=4 \text{ calories}$$

approximately.

You know that when a gas is compressed it is heated, and that when it expands it is cooled, and that the cooling is independent of the time it takes to make the expansion, provided there is no way of renewing the heat. We know that as we ascend the pressure of the air gets less, and so the vapor, in rising, is cooled, and thus supplies at its own expense the energy required to lift it to the elevation. The energy required (4 calories) would be obtained by the air cooling 4° C. That is less than the average fall in temperature for that height. The vapor has next to be transported to the place where it is to be deposited; but as this is brought about by the pressure distribution of the atmosphere, it is not necessary for my purpose to consider it, nor what becomes of the heat that is given out by the vapor on condensing (this is equal to the heat required to evaporate the water), except to call your attention to the immense amount of power that is liberated for maintaining the energy of the cyclone or the agency that is producing the rainfall.

This shows, then, that it requires energy and a vast amount of it to produce rain, and that the only source that produces sufficient energy for the purpose is the sun. What I wish to emphasize strongly is this: that all the various phenomena which constitute our weather are not caused by mysterious or magical forces, nor by the position of the stars, but they are produced solely by transformations of energy from one kind to another, according to the known laws of physics. We cannot interpret all the phenomena of the weather yet, largely because we do not fully know them. In astronomy you all know how many and varied were the motions devised to account for the true motions of the heavenly bodies, and while these held sway no progress was possible in regard to discovering the laws governing them; but when their true motion was discovered it was very soon followed by the correct theory, and the enunciation of the laws of gravitation.

Before it will be possible to formulate correct laws for weather phenomena, such as cyclones, etc., it will, first of all, be necessary to know the atmosphere, especially its circulation; then when this has been discovered, it may be possible to get the correct laws which govern the weather, and it will again be simply a matter of calculation to find out what the weather is going to be. The difficulties are, however, very great.

*From the *Journal* of the Royal Astronomical Society of Canada.

Health of Hog Versus Health of Man

IN one county of California the health officer receives a salary of $25 per month, while the county veterinarian receives $125 per month. The board of supervisors even went so far as to dispense with the health officers' services altogether, but finally reconsidered, after attention had been called to the law. None can deny that the health of domestic animals is of great importance, but is it of so much greater importance than the health of human beings?—*Bulletin of the California State Board of Health.*

Some Familiar Bird Friends*

The Nuthatches and the Chickadees

By A. A. Allen, Ph.D., Assistant Professor of Ornithology, Cornell University

CLOSELY related and formerly placed in one family (*Paridae*), the nuthatches and the chickadees are associated in more than name, for after the nesting season they gather in loose flocks and spend the cold winter months together. Seeming to enjoy their company, other winter birds often follow them, so that when one hears the *yank-yank* of the nuthatch and the scolding *chick-a-dee-dee* of the chickadee, he may look also for the slender brown creeper winding its way up the bole of the tree, the downy and hairy woodpeckers, the golden-crowned kinglet, and often for a merry troop of tree sparrows. Not only are they sociable among themselves, but for mankind they seem to have little fear, and gather about suburban dwellings wherever food is offered them.

Except in northern Canada, most species are nonmigratory and spend the winter in the vicinity of their summer homes. If one wishes to have them about the garden all through the winter, he should begin putting out sunflower seed and pieces of suet, as directed in *American Forestry*, December, 1915, in October or November, because it is at this time that their numbers are increased by the visitors from the North, and where they find an abundant food supply they are apt to remain all through the winter. When one has been feeding the birds for several seasons, there is every reason to believe that the same birds return year after year to the same feeding stations, just as it is known that they return to the same nesting spots. Members of the American Bird Banding Association, as reported by the secretary, Mr. H. H. Cleaves, have placed bands on the legs of several species of birds trapped at feeding stations during winter, and have recaptured the same birds in the same traps the following winter. The author has placed bands upon the legs of chickadees and nuthatches coming to his window during the winter and has had the same birds nesting in the vicinity the following spring and bringing their young for food to the same window the following fall.

The garden in which sunflowers have been planted will do more than anything else to attract the nuthatches and chickadees because both are more fond of these seeds than anything else. The sunflowers can be left standing or the seed can be used at the window shelf with equal effectiveness. The oils in the sunflower seed and the fat of the suet seem to take the place of insects, for both birds are insectivorous, and when not actually at the feeding shelf spend their time gleaning about the trees for hibernating larvae and insect eggs. During the summer they feed almost altogether upon insects and it is, therefore, very much worth while to expend the little effort necessary to entice them to the home grounds.

There are 241 species in the chickadee family, found in most parts of the world except South America and the Pacific Islands, but most abundant in the northern hemisphere. In North America there are but fifteen species represented, extending southward into the mountains of Mexico. Of these six species are known as chickadees, four as titmice, three as bush-tits, one as a wren-tit, and one as a verdin, but all are alike in being small fluffy birds with long tails and sharp, pointed bills. The chickadees are dull grayish birds, lighted below, with conspicuous black crowns and throat patches. The Hudsonian chickadees, of the Far North and the mountains of Northern United States which come southward in winter irregularly, have the top of the head brown rather than black, and the mountain chickadees of the Rocky Mountain region have a white stripe over the eye, but all six species are easily recognized by anyone familiar with the common chickadee. In fact, the Carolina chickadee, of the Southern States, is so similar in appearance to the common chickadee that it can scarcely be distinguished from it in the field. The songs and call-notes of the different species vary considerably but all have a common likeness. The scolding call of the common species gives the name to the family, for it is a clearly enunciated *chick-a-dee* or *chick-a-dee-dee*. In other species it is less clear, more highly pitched, or more nasal. In addition to this note, the chickadee has a song of two or three sweet whistles resembling the syllables *phe-be* or *phe-be-be*, so exactly that amateur bird students are often led to believe that it is a phoebe calling. Also, as the chickadees troop through the woods, they have a variety of conversational notes rather difficult to describe. When protecting its eggs or young, the chickadee utters a hissing or sputtering sound, if disturbed, which is sufficient to discourage any unsophisticated squirrel from further investigation of the contents of the hole.

During March and April the flocks break up and pairs of chickadees can be seen prying about decaying stubs or old woodpecker holes looking for a place to build their nests. Even though their small bills do not seem adapted to chiseling, they usually find a stub sufficiently decayed for them to excavate their own cavities. During recent years, however, they have come more and more to accept bird houses such as those built for wrens. At the bottom of the cavity they build a warm nest of vegetable fibers, moss, plant down, wool, etc., and lay often as many as nine tiny speckled eggs. What is more remarkable, they often succeed in rearing all nine youngsters.

In spite of the fact that they begin selecting their nesting site in March or April, the eggs are not laid until May, but the young are out of the nest early in June, giving them time for another brood, which, however, is usually smaller than the first.

The chickadees are friendly, inquisitive birds and it is not only at the winter feeding stations that they become tame. They are always ready to answer an imitation of their *phe-be* call and will come flying through the woods to greet the traveler, perching on the branches above his head, sometimes even dropping to his shoulder or hovering a few inches in front of his face in a vain endeavor to discover the whereabouts of the other chickadee.

The titmice, as the name is now restricted, differ from the chickadees in having the crown feathers elongated in the form of a crest. The tufted titmouse of the East and the plain titmouse of California and Oregon are the best known species, the other two being Mexican, and coming into the United States only in Texas and Arizona. The tufted and the plain titmice are uniformly gray, a trifle larger than the chickadees, but with the same cute ways of flitting about the outer branches, hanging upside down, peering under leaves, and examining the crevices of the bark. The loud whistled call of the tufted titmouse, *peto-peto-peto*, is one of the familiar sounds of the southern woodlands, while the *tu-whit, tu-whit, tu-whit* of the plain titmouse is always associated with the live oaks of California.

The wren-tits and the bush-tits are browner birds than the chickadees, the wren-tit being more or less wrenlike in its brown garb and its habit of holding its tail tilted upwards. The bush-tits are mere sprites of bird life, over half of their length of four inches being tail, so that their bodies seem scarcely larger than the end of one's thumb. In habits they resemble the chickadees with the exception that they build long purse-like nests of soft materials, hanging them usually in thickets of ash and willow.

The verdin is quite similar to the bush-tit in size and habits, but its whole head, neck and chest are bright yellow. It lives in the mesquite valleys of the Rio Grande, the Colorado, the Gila and the Pecos Rivers of the Southwest where, from the thorny bushes, it scolds and sputters at every intruder.

Like the chickadees, the nuthatches are largely confined to the Northern Hemisphere. There are about seventy species, of which only four are found in North America. They are bluish-gray birds, brighter than the chickadees, with white or rusty underparts, and with the top of the head brown or black. The chief characteristic of the nuthatches is their habit of climbing the trunk and larger branches of trees in search of insects, upward or downward with equal facility. Unlike the woodpeckers, they do not use the tail as a prop, nor are their feet arranged with two toes for-

*Courtesy of *American Forestry*.

Plant sunflowers to attract the friendly chickadee

The chickadee is very fond of the seed and the flowers may be left standing, or the seed removed for use at the window feeding-shelf

A winter chickadee

If you'd like to have them stay with you all winter, just provide plenty of seed and suet, for snow and ice hold no terrors for this winter sprite, but food must be provided

A perky member of a family of nine

There is no danger of race suicide among chickadees, for large families are the rule, and this one looks fully able to paddle his own canoe

"In union there is strength." More power to 'em!

Chickadees and nuthatches are associated in more than name. After the nesting season they assemble in loose companies and make common war upon hibernating insects — and here they are, hard at it

ward and two backward. Instead they have the ordinary perching type of foot with three toes forward and one backward. Both the toes and claws, however, are, of necessity, much better developed than in ordinary perching birds. Certainly they seem to have no difficulty in spiralling about the trunks of trees and, in fact, they have been known to sleep hanging head downward, clinging to the bark beneath a jutting limb. They are lively little creatures, always on the move, peering at one from strange angles, and their contented *yank-yank* adds much to the cheerfulness of the northern winter. The name nuthatch is supposed to be a corruption of *nut-hack*, derived from their universal habit of wedging the bark and then hacking them open. The white-breasted nuthatch is the commonest species and is found throughout United States and Canada from the Gulf States to Central Ontario, preferring open woodlands, roadsides and gardens. It is pure white beneath, except for the under tail coverts which are reddish brown, and bluish-gray above, the top of the head and neck being shining black. In the female the black is more or less veiled with gray.

The red-breasted nuthatch nests only in the northern part of its range from northern United States to Alaska, but, in winter, it wanders as far south as the Gulf States. It is somewhat smaller than the white-breasted species, having the entire underparts, except the throat, rusty, and having a white stripe over the eye. It has a partiality for pine trees but, like its white-breasted cousin, it comes freely to the window for suet and sunflower seed. Its notes are very similar but higher pitched and more nasal like the syllables, *yna-yna*.

The brown-headed nuthatch is confined to the southeastern United States from Delaware and Missouri to Florida, frequenting the extensive pine forests. It is smaller even than the red-breasted species, and its notes are different from either of the preceding, a conversational *pit-pit* and a scolding *tee-dee-dee*, being the most familiar.

Similar in appearance and habits but still smaller, measuring sometimes less than four inches in length, is the pigmy nuthatch of the Rocky Mountains.

The nesting habits of the North American nuthatches are much alike. They usually select a knot hole in the trunk of a tree, occasionally a woodpecker's hole, and line it with feathers, leaves, wool, etc. They lay from four to nine white eggs, which, differing from the majority of hole-nesting species, are heavily marked with brown. The common European nuthatch has the curious habit of plastering up the entrance to its nest with mud until the opening is just the right size, and the American red-breasted nuthatch usually decorates the entrance with nodules of pitch as if to make the entrance less attractive to squirrels and other enemies.

Evolution of Cable Making

THE development of cable making in England was recently discussed in an interesting manner, largely historical, by J. Phillips Bedson before the Manchester (England) Association of Engineers, in a presidential address. There were interesting allusions to the industry in America in its early days. An abstract by the London *Ironmonger* follows:

Puddled iron was formerly used in the wire trade for all common purposes, such as a low-grade telegraph wire, armor for submarine cables, and fencing; but for the higher grades at this time English and Swedish charcoal irons were required. The former was made in the South Staffordshire district and in Shropshire, and the latter in Sweden, in what was known as a Lancashire hearth. It was imported into this country in blooms, billets and wire rods. In 1850 the first experiments in submarine telegraphy were made by the laying of a cable between Dover and Calais, and from that date the wire trade found an ever-increasing demand for its product. Before long the idea of an Atlantic cable was mooted, and in 1856 the Atlantic Telegraph Co. was formed. An unsuccessful attempt was made to lay such a cable in 1857 with wire which was drawn from Bradley rods in a Manchester works. Mr. Bedson traced the steps that led to a successful issue.

The speaker stated that the wire industry in America would always be intimately associated with the name of John A. Roebling, who built the first two wire bridges in the United States. The wire for these was drawn at Manchester. One bridge was at Cincinnati, the suspension cables weighing 500 tons, the breaking weight being 6,500 tons, and the diameter of each 12½ in.; each cable was composed of 5,200 wires and was 1,700

An upside-down nuthatch

Nuthatches travel upward and downward with equal facility and never use the tail as a brace, as do the woodpeckers

ft. long. The other was the Niagara Railway Suspension Bridge, at Niagara Falls. Both were made of charcoal iron, and they set the type for the graceful wire bridges which span the East River between Brooklyn and New York today. The Cincinnati bridge is still in use, but the Niagara bridge, which was erected in 1855, was replaced in 1897 by a new bridge to meet the increased traffic. Each of its four cables contained 2,640 parallel wires 0.145 in. diameter, making a total strength of 11,996 tons, on a basis of 1,648 lb. for each wire. The actual strain in the bridge at the towers was 6,180 tons, which correspond to a factor of safety of 4.41. This increased at the center of the span to 7.83. During its 42 years of service it had been subjected to increased loads, so that the final strains were considerably in excess of those given. When the cables were taken down the wire was tested, and the average of 12 tests showed an ultimate of 1,566 lb. for one wire, which was equal to 42 tons per sq. in., or 95 per cent. of the original strength. Such was the care of the cables that the wires were almost as bright when taken down as when first thrown over the river.

This early work was done with comparatively small wire rods, which were put up in 14-lb. coils. Obviously some better method of manufacture was the next stage to be tackled, and the difficulties were solved when in 1862 the late George Bedson was granted a patent for a continuous system of wire-rod rolling mill, whereby rods were rolled in 1-cwt. pieces. That result had since been increased to 3 cwt. in one continuous length. There were three patents in his mill, covering three leading features:

The door of the heating furnace, which was placed immediately in front of the first pair of rolls so that the heated billet when placed in this first pair of rolls would draw the remaining length out of the furnace.

The placing of the rolls, 16 in number, in a line, so that No. 1 roll delivers into No. 2, and so on through the remaining 14 rolls, each roll being graduated in increased speeds to suit the acceleration of the reduced size of the billet as it progressed down the mill, where the outcoming round rods were coiled up on suitable reels. This idea was suggested to Mr. Bedson by the drawing frame of textile machinery.

The twisted guide, where needed, to present the partly rolled rod to the succeeding pair of rolls, although this was only required once in the first mills in rolling iron.

The rolls in the original mills were placed horizontally and vertically alternately to give the requisite compression on top and sides. An experimental mill erected in the Adelphi, Salford, in 1863 proved a success and it was then removed to the Bradford ironworks, Manchester, where it ran until 1884. A second mill was built in 1866, part of which is running today. —*The Iron Age.*

The Cheese Mite

THE cheese mite is the cause of much damage to cheeses, especially the unpressed, ungreased cheeses of the Stilton and Wensleydale types. The attacks of this pest give rise to a serious depreciation, both in appearance and value, and in extreme cases nearly one-half of the cheese may be eaten away. An interesting account of experiments and observations on this problem is contributed by Miss N. B. Eales, of the Zoology Department, University College, Reading, to the January issue of the *Journal of the Board of Agriculture*. It was demonstrated that live mites persist in the cheese room throughout the period from December to April when the room is not in use, despite the greatest care in the application of the ordinary cleansing methods. Further experiments showed that the mites could be carried by flies and moths. The common practice of dipping mite-attacked cheeses in hot water or steaming them was found to be useless as a remedy. Fumigation with sulphuretted hydrogen or sulphur dioxide was also futile. Treatment with carbon bisulphide proved very successful, but treatment with formalin was ineffective. In an experiment with carbon dioxide the mites revived after a period of suspended animation lasting for ninety-six hours. Methods of prevention of mite attacks are indicated, and the article also includes brief notes on the systematic position, species and life-history of the mites.—*Nature.*

A careworn mother

There are nine young hopefuls inside this hollow stump, and they demand so much attention that they allow her little rest

The Employment of Women in Munition Factories*

By Miss O. E. Monkhouse, M.B.E., B.A.(Lond.).

AT the beginning of the war it was an exceptional thing for women to be employed as general machinists and fitters in engineering shops, but the demand for a greatly increased supply of labor of all kinds for munitions production, and at the same time the necessity for conserving the man-power of the country to the fullest extent, made it necessary for the government to turn to the largest source of supply of unskilled labor, namely, women. The successful employment of women in engineering works depends not only on the unskilled woman, but in an almost equal degree on the skilled man, and the employer.

The Employer.—The successful employer of women labor faces the question of dilution squarely, and recognizes at the outset that the psychology of the woman worker is different from that of the man. Next he fixes on work suitable for his new type of employee, and then determines the quickest and easiest way to train her in the work. He assures himself of the extent to which the men will cooperate, and is always careful to provide suitable shop conditions and plant, etc. Having made these preliminary arrangements, he realized the necessity for carefully choosing the right class of labor, and his next step is to appoint a woman of experience to engage and look after the women, and to select as their technical overseer a foreman who he knows is sympathetic with his new venture.

The Skilled Man.—The skilled men have to do the technical training, and have to use all their brains and skill in order to train inexperienced women. They have to sectionalize work, adapt machinery and simplify operations so as to make it possible to employ women. In their hands is largely the power to oppose and retard all progress by women on skilled work, because at the outset hardly a single woman is in a position to know when obstacles are being placed in her way. She perforce has to rely entirely on their generosity, and her position in engineering shops today shows that she has not relied in vain.

On the other hand, it must be remembered that every man does not make a teacher, and that every teacher of men is not necessarily a suitable teacher of women. Thus the unequal success of women in different shops is due in a measure to this cause as well as to antagonism on the part of the men.

The Unskilled Woman.—The successful woman worker in an engineering works has a great deal to learn, because in addition to learning her work she has to acquire correct work habits, and face obstacles both necessary and unnecessary which are constantly put in the way of her becoming efficient.

There are, however, three grades of unskilled women who must be taken into account:

1. The educated type.
2. The domestic type.
3. The ordinary factory type.

The educated type come with trained brains; they know how to learn and how to apply their knowledge. They probably have mathematical training and can be taught in a very short time how to use a slide rule, a micrometer and other gauges. Fine limits present no difficulty to them, and in a sense they may be regarded as already half educated for the better class of engineering work.

The second type, namely, the domestic type, drawn mostly from the daughters of small tradesmen, generally have a good deal of sound commonsense, are reliable, and enjoy, and so aim at securing, some position of authority. Such people train quite readily into good charge hands and forewomen.

The factory type are different from either of the other two—they are mainly concerned with making as much money as they can, and preferably on piecework. For the most part they resent being put on to a new operation because, every time they learn anything fresh, it means a temporary set-back in wages. It has therefore been found best to employ such workers on purely unskilled work of a repetition nature.

But no matter what the type of unskilled women, it must always be borne in mind that their success depends largely on the judgment of the management in selecting a good class of women labor. At the present moment there are, roughly speaking, close on 1,000,000 women employed on the production of munitions of war.

The introduction of all these women into engineering shops meant that a great many difficulties had to be overcome. These may be briefly summarized as follows:

1. A very large proportion of the women employed not being accustomed to factory life and discipline.
2. The majority of works managers and foremen not being accustomed to managing women workers.
3. The shop conditions for the most part planned with a view to the employment of men.
4. The use of the machinery to which women have hitherto been unaccustomed.
5. The difficulties of maintaining discipline in a mixed shop and in entirely female shops staffed by women of no previous factory experience.
6. The long hours.
7. The question of physical strength.

Many of these difficulties have been overcome by careful selection of suitable work, a careful choice of labor, proper shop organization, conforming to definite welfare standards, installing or adapting plant suitable to women's use, supplying proper training facilities, sub-dividing skilled work and adapting the hours of employment in accordance with the class of work done.

How Women Have Reached their Present Skill.—At the stage which women have reached at the present moment in engineering, nothing but harm can be done by praising their powers too highly, but there are many individual cases where women have shown very great ability, and have acquired a knowledge of a certain branch of engineering work in excess of what would have been learnt by an apprentice in the same period under pre-war conditions. This state of affairs may be attributed very largely to three causes: (1) Women have been definitely taught, whereas the apprentices had to pick up their trade. (2) Women have, for the most part, been intensively taught everything in the shop itself under production conditions rather than in the school. (3) The conditions of the time have actuated and spurred on everybody to greater effort, from patriotic motives.

Training of Women Workers.—There is little doubt that the advantage of getting their training under production conditions has been very largely instrumental in considerably speeding-up women's training, and the author would like now to consider some of the methods in use for training women workers.

Women Trained in Works in a Separate Shop.—It is extremely difficult to start women in the same shop with men, unless the latter are in sympathy with the movement, and experience has proved that the only satisfactory way is to start women in a shop by themselves under a sympathetic foreman until they have proved themselves. In illustration of this the author can quote a firm who, up to last April, had no women bench fitters on aircraft work. They have adopted the above plan, and there are now 200 women fitters in the shop controlled by women charge hands, all doing exceedingly well.

Overcoming of Incredulity on Part of Management.—Another type of case which should be mentioned is that of firms who cannot believe that women can do anything but purely repetition work, and regard a woman fitter, tool-turner or tool-setter as an impossibility. It therefore is no use telling them that they must up-grade their women on to better work; they have to be shown that women are available in numbers who can do such work. In such case the ministry often sends to the firm an expert woman demonstrator. She will first of all do the job herself in the shop to prove its practicability, and she will then continue to assist the firm by training some of their best operators or helping them to select others who are suitable. There are many firms which, having been assisted in this way, have become some of the most successfully worked shops in the country, not only from the point of view of percentage of women labor but of record output as well.

Other Successful Methods of Training Women Workers.—It would take up too much time to go through at length all the various methods which have had to be adopted in order to make women efficient in the shortest possible time. Government training schools have done much by supplying a nucleus of semi-trained labor to shops desiring either to make a start with women labor or to introduce women on to some new class of work. Just a few large firms have done the ideal thing and set up their own training schools, from which they have a continual flow of semi-trained labor always ready to draw upon.

Characteristics of Women.—All consideration of women's work must be accompanied by a careful appreciation of the mental and physical characteristics of women. They have shown great adaptability and natural skill in successfully undertaking work of an entirely new character, but the varying degrees of success points to the necessity for thoroughly understanding their peculiar temperament if the best results are to be obtained.

Shop Organization.—Firms, who with male labor have been thoroughly successful, have failed when forced to employ women labor, thus proving that they did not understand their new employees. Other managers have not recognized their own failings clearly, and numerous cases can be quoted where the want of success of women labor has been traced to defective shop organization. By this term is meant the question of supervision and direction of the work in the factory—work usually performed by foremen and male charge hands. A foreman may be an admirable foreman of men, and at the same time an unsuitable foreman for women, apart from the question of his technical ability. There is no doubt that women do need special management, and it is folly to disregard the human element, as some do, by asserting that if women are to be employed on men's work, they must be treated the same as men. In one sense this is true. Discipline and strict adherence to work should be expected from women just as much as from men. As a rule men are either too lenient or too stern in their treatment of women, or too busy to study their peculiarities, and experience has shown that women should be controlled and organized by their own sex if the best results are to be obtained.

Shop organization, however, even when performed by women, may be quite unsuccessful if proper judgment is not used when selecting people for this work, and this brings up the general question of the choice of woman labor.

Choice of Labor.—There is no doubt that generally speaking a woman is a better judge of a woman than a man, and successful firms have realized this and have appointed an experienced woman supervisor, to be responsible for engaging all their women labor. Very recently a case came to the author's notice of a factory where one side of the labor was chosen by a woman and the rest by a man. There was great complaint of the efficiency of the latter, but none of the former. Investigation showed the cause that those women who were "turned down" by the woman supervisor were generally engaged by the man.

Ordinary Labor.—In the choice of ordinary operatives, stability of character and suitable physique must be the main considerations, but different characteristics must be taken into account when choosing forewomen and charge hands. It is most essential that such people should have shop experience coupled with a certain amount of technical knowledge, and a thorough knowledge of how to manage women, and ability to hold their own in the shop. Women taking up this work must have tact and discretion, and the necessary power to enable them to work in harmony with the shop manager, whose authority should not be interfered with. Generally speaking, the most successful forewoman and charge hands have been drawn from the more educated classes. For it must be remembered that women as a whole have been introduced very quickly, in very large numbers, without proper training or proper discipline, and it needs someone with powers of leadership and organization to get the women labor going on a proper footing.

Welfare.—Placing in factories in such large numbers women, many of whom have never been accustomed to factory life or conditions, has also called for special considerations of welfare conditions on the part of the employers. In considering this question two points of view must be taken into account: (1) Effect of Welfare on Production; and (2) Effect of Welfare on the Race.

Effect of Welfare on Production.—Employers have now for the most part fully realized that to give their women good welfare conditions is a sound business proposition. Without such provision they cannot get a good class of labor. The unwonted heavy muscular effort and constant strain through which they are working makes it essential that their off times should be restful, if good work is to be done after the break. Good canteen accommodation also is most important, and there have been cases where managers have found that to provide one good meal a day free of cost has been more than repaid to them in output.

Welfare on the Race.—But quite apart from the effect of welfare on production is the effect of welfare on the race. From the national point of view this is the most important aspect to consider. For this reason the Health of Munition Workers' Committee was formed, whose special care was to safeguard any deterioration of the race which might perhaps ac-

*Paper read before the Institution of Mechanical Engineers. Reproduced from *Engineering*.

crue from women being compelled to work in all great industries. They have considered carefully (1) the hours of work; (2) rest periods and provision for meals; (3) sanitary conditions of the factory; (4) physical condition of women workers; (5) questions of management and supervision.

Hours of Work.—With regard to hours of work, experience has shown that a reasonably short shift is the most successful, producing less industrial fatigue as shown by few accidents, better timekeeping, and undiminished capacity of the worker towards the end of the shift so that a better average output is maintained. Another point in favor of shorter hours is the fact that a better class of labor is tempted to join the ranks of munition workers.

The other problems the committee have considered in full detail, and the result of their investigation has shown that the nation is under a definite obligation to consider women's health and comfort in the factories if they are to protect and safeguard their position as the mothers of the race. Experience has shown that wherever there has been proper consideration for women's welfare in factories that there has been not only no decrease in healthy physical development, but a decided increase in mental capacity. It has been an enormous advantage for women to have had this opening into a wider field of skilled and semi-skilled work, and the country has benefited by a tremendous increase of industrial efficiency.

It must be remembered that a woman's work is not ended when she leaves the factory. On her largely depends the life and happiness of the nation in creating and developing a happy, healthy family life, and it is her privilege to care for the physical and spiritual welfare of the race. Added industrial efficiency therefore at the expense of women fulfilling their primary duties in their homes and to their children cannot result in anything but national disaster, and it is a sacred duty of the State to ensure that women are only used as wealth producers in so far as it does not affect the healthy development of the race.

Merchant Ship Design and Torpedo Attack

NEARLY two years ago the Council of the British Institution of Naval Architects appointed a committee to inquire into the effects of explosions of mines and torpedoes on the structure of merchant ships, and the principal recommendations of the report of this committee were embodied in a notice to shipowners and masters issued by the Board of Trade last year; the report itself, however, has been withheld from the public until recently.

A discussion of this report appears in a recent issue of *Engineering*, and as it covers the matters contained in the report in a way to be understood by the general reader, and as the subject is equally as important to us in America as to the British, this excellent article is presented as follows:

"So long as merchant ships were unarmed nothing short of a complete system of convoy could prevent them from being sunk by submarines. Single vessels could be overhauled by a fast U-boat running on the surface, and sunk either by gunfire or by bombs placed on board without the expenditure of a single Whitehead torpedo, and the most perfect subdivision would have failed to save them. But as soon as they were armed the case was altered. The U-boat could no longer overhaul them as her submerged speed was insufficient to enable her to do so, and she was compelled to attack with the torpedo. It is impossible to provide a convoy for every vessel, and if by any means the ship can be enabled to survive the blow of a single torpedo an important object will have been achieved. No doubt in some cases the submarine would discharge a second torpedo in order to complete the destruction of the ship, but it should be remembered that there is always the chance of assistance arriving in time to prevent this, or the submarine may have exhausted her necessarily meager supply, and in any case, if she is forced to expend two torpedoes on each ship instead of one, the number of vessels she has it in her power to sink is at once reduced by half.

"When the council decided to appoint their committee there were many who believed that the structure of a merchant ship could not be expected to withstand torpedo attack; that the shattering effect of a modern Whitehead was such as to destroy the watertightness over large areas of the shell plating extending beyond the watertight compartment attacked, and that in all probability the dynamic effect of the sea entering through very large holes carried away the bulkheads. The committee's investigations disposed of both these theories. It was found possible to establish the maximum size of the hole made by the torpedo and to prove that the riveting of the hull within a few feet of the edge of the hole was not disturbed. In no case has a bulkhead constructed according to Lloyd's rules been found to have given way from water pressure alone. They found that in a large majority of cases the loss of the ship was due to the flooding of compartments outside the injured area from causes which were easily preventable.

"Very many merchant ships carry coal in a reserve bunker forward of the boiler-room in addition to that carried in side bunkers in the boiler-room. This reserve bunker is partitioned off from the cargo hold by a non-watertight bulkhead. The reserve coal is used during the outward voyage, being worked through watertight doors in the forward boiler-room bulkhead. On the return voyage the reserve bunker is used for cargo. If the vessel is torpedoed either in the engine or boiler-room, or in the hold containing the reserve coal while the coaling doors are open, the probability is that the vessel will sink. There is very little hope that these doors could ever be closed after an explosion, as it has been shown that they are liable to be immediately choked with coal washed out of the bunker. Indisputable evidence was found by the committee of the danger of using these reserve bunkers at sea, and they recommend that the watertight coaling doors should be permanently closed and so secured that they cannot be opened while at sea.

"They found that the second cause of the loss of many vessels is the watertight door in the engine-room bulkhead leading to the shaft tunnel. This door is usually provided with means for closing from the upper engine-room platform, but cases have been investigated in which an explosion in a hold abaft the engine-room has destroyed the tunnel, resulting in the immediate flooding of the engine and boiler rooms. Even if there were time to close the door from the platform it has been found that portions of the cargo are washed under the door and prevent its closing. In one such case inspected the ship only owed her safety to the fortunate circumstance that the reserve bunker was not in use at the time and, therefore, the flooding did not extend further forward than the boiler-room. There have been cases where water has entered the after holds through a leaky tunnel when the engine-room was flooded. When it is remembered that the flooding of the engine-room usually plunges the ship into darkness the danger of depending on the closing of doors is apparent. The council, therefore, recommended that doors to the shaft tunnel should be permanently closed and access provided to the tunnel through a watertight trunk abaft the engine-room bulkhead. This involves a little more trouble to the greaser on his periodical visits to the tunnel, but should be unhesitatingly insisted upon by the Board of Trade during the continuance of the war.

"Another danger lies in the main drain pipes leading from the bilge pumps to the different compartments and passing through all the watertight bulkheads. These pipes are generally found fractured in the torpedoed compartment, with the result that water flows into other uninjured compartments. All that is required to prevent this is the provision of non-return valves on the ends of these pipes. One other precaution is all that is considered necessary to give the ordinary merchant ship a very good chance for safety. This is to protect the bulkheads as far as possible from flying splinters. Although a ship may have her bulkheads spaced so closely as is required to secure her safety in case of any two adjacent compartments being thrown open to the sea, there is risk of the bulkheads at each end of a torpedoed compartment being penetrated by flying splinters which might cause the loss of the ship through the filling of three adjacent compartments. They therefore recommend that wherever possible the bulkhead should be protected temporarily by means of timber or other suitable material forming a splinter screen. When the holds are full the cargo itself affords protection, and by careful stowing the best advantage can be taken of this.

"As compared with the cost of making good the loss of a dozen or more large vessels a week, the cost of carrying out these three or four simple requirements is negligible.

"The second part of the report deals with 'Existing large mail and passenger vessels.' There is no doubt that the public have been greatly disappointed and dismayed at the readiness with which vessels of this type, although of the largest size and latest construction, have gone to the bottom when struck by a torpedo. Representing as they do the best examples of the naval architects' and builders' skill, they were expected to be able to survive the explosion of a mine or torpedo in any part of their structure. It is not surprising that people have asked themselves whether there can be anything wrong in the principles which have guided naval architects in the provision of the necessary buoyancy and stability to preserve the safety of the ship under apparently the very circumstances in which she has found herself, namely, with one or two compartments open to the sea. There is nothing wrong in the principles. Ships can be made safe, but that they are not safe now is shown by the terrible regularity with which, after a longer or shorter interval, the loss of the ship follows the explosion. The fault does not lie with the naval architect.

"The fact is that, as the chairman of the committee has pointed out, startling as the statement may appear, large passenger ships are not divided into watertight compartments, but into compartments which are capable of being made watertight. For the convenience of the passengers and crew nearly all the watertight bulkheads are pierced by doors, most of which are normally open, but which are intended to be closed on emergency. Many of the latest and best ships are provided with means for closing all watertight doors simultaneously from the bridge, and under pre-war conditions, when the danger was principally from collision, there would usually be time to make use of these appliances, thus completing the subdivision of the vessel. Even if the doors were not closed actually before a collision took place, the bow of the striking ship might be expected to stop the hole for a short time and so give an opportunity to close them before much water enters. But in the case of a torpedo explosion such an enormous hole is opened instantaneously that there is no time at all for closing doors. The council point out that an explosion which wrecks a compartment is likely to destroy the mechanism of any system of bridge control, and also to distort the neighboring bulkheads, and thus prevent the doors from being closed. Moreover, collisions are of rare occurrence, and usually take place in foggy weather, when special precautions could be taken, whereas the torpedo danger is ever present. The report calls for the closing up of all doors in transverse bulkheads below the bulkhead deck and for the provision of additional exits to the decks where necessary. In fact, during the continuance of the war, instead of waiting until after the blow falls before the ship is properly subdivided, she should never be allowed to be caught in any other condition.

"One of the largest and most splendidly equipped vessels employed as a hospital ship sank by reason of an excessive list and change of trim forward following an explosion, which brought the lower deck side-scuttles under water. These were open for ventilation, and water poured in through one after another in succession. Hence the recommendation that all scuttles below a certain height above the water-line should be permanently closed, artificial ventilation being provided where necessary. Particular attention is directed by the report to the danger arising from the existence in many of the largest mail steamers of tunnels connecting the boiler-rooms with the firemen's quarters forward so that these men may get about the ship without passing through any parts where passengers may be. Such tunnels give away the whole security of the ship and ensure her rapid foundering if the opinion of the council is correct that the provision for closing watertight doors in them cannot be depended upon. At least two cases have occurred in which vessels fitted as hospital ships have sunk after reaching shallow water, due to water entering the ship through baths, wash basins, W. Cs., pantry sinks, etc. These vessels would otherwise have remained afloat. As it was, their salvage was only due to their having been torpedoed near a port.

"All the recommendations of the council are intended to have effect only during the continuance of the war. The owners of one line of large passenger steamers have carried out the whole of the recommendations of the committee for an expenditure on each vessel of considerably less than half the cost of a single Whitehead torpedo, and the work was done while the ships were in port between voyages without interference with their time tables. It is probable that in some ships a greater expenditure would be necessary, but in view of the importance of endeavoring to save vessels rather than to build them faster than the enemy can sink them we do not think it could be more than would be justified."

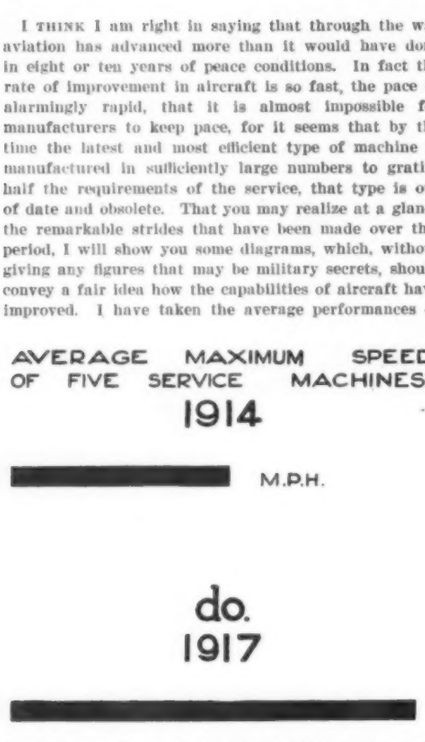
Linen Disappearing.—The enormous demand for linen for covering aeroplane wings is rapidly absorbing the visible supplies of the world, and it may be years before this material can be bought at a reasonable price.

War Aviation*

Reviewing the Flying Experience of a British Expert

By Captain B. C. Hucks

I THINK I am right in saying that through the war aviation has advanced more than it would have done in eight or ten years of peace conditions. In fact the rate of improvement in aircraft is so fast, the pace so alarmingly rapid, that it is almost impossible for manufacturers to keep pace, for it seems that by the time the latest and most efficient type of machine is manufactured in sufficiently large numbers to gratify half the requirements of the service, that type is out of date and obsolete. That you may realize at a glance the remarkable strides that have been made over this period, I will show you some diagrams, which, without giving any figures that may be military secrets, should convey a fair idea how the capabilities of aircraft have improved. I have taken the average performances of



five different types of service machines used at the beginning of the war and compared them with the average performances of five different types of late patterns now in use in France.

The first diagram represents the growth in three years of the maximum speed capacity flying level.

The second diagram consists of two curves showing the increase in machines' capacity for climbing against time.

The next diagram represents the growth of horse-power developed by aero motor engines.

And lastly, the increase in the number of certified pilots during the past three years.

A pilot has only to take a short flight on a 1914 type machine and then fly the latest 1917 pattern as a comparison to really appreciate this colossal advance.

Some little time ago I had occasion to again fly, after a considerable lapse of time, a 50 h.p. Gnome Blériot, a one-time premier machine, in fact a type used quite a lot by ourselves and the French at the very beginning of the war. At first I believed the machine to be a very bad specimen of the species, but ultimately, after flying it for some time and acquiring a sort of lost art of balance, like a skater who has not skated on ice for years and has to get his legs again, I realized that it was quite a good specimen of the type, but that it takes quite a time to again get used to such inefficiency. The advance seems to have been along, one might say, quite conventional lines—that is, improvements on what might be accepted as standard designs—and no good results have been obtained from any departure from that standard. Perhaps the furthermost departure from what I call standard, and that is very slight, has been the triplane. The results obtained with the quadroplane have not justified the experiment.

During the past three years the first marked improvement, to my mind, which asserted itself was the inherently stable machine, attained apparently by such slight detail alterations as sections of planes and elevators that it required an experienced eye to detect a stable or unstable aeroplane by casual inspection when standing together. Then came the synchronized timing gun-gear which enabled the machine gun to be fired through the propeller on tractor machines. This device is really so simple that one is at a loss to understand why it had remained so long undiscovered. It had the effect of giving the tractor type of machine a new lease of life; although a more efficient type aerodynamically than the pusher, it had been falling into disfavor as a fighter on account of the inability of the pilot to shoot straight ahead of the machine.

Improvements in engines, to my mind, are responsible for present-day performances to a far greater extent than improvements in machines, chiefly through sheer increase of horse-power, as my diagram shows. And cases have occurred where certain obsolete types have been made serviceable simply by fitting an improved type of engine.

The improvements in the machines themselves seem to have been limited to details, such as wing sections, attention to head resistance, soundness of construction, etc.

The very efficient freak machine has yet to make its appearance.

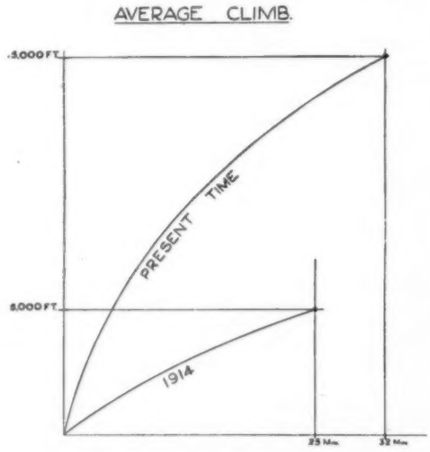
I will not attempt to discuss the future of aviation, but setting aside the boundless commercial possibilities, I am more and more convinced that if we find it necessary to keep up an enormous navy, say a two-Power standard to protect our island, it will be essential to maintain at least the same standard in the air. That in itself guarantees a colossal future for aeronautics.

But to return to the subject of my paper tonight, I would like to place before you a few points as I have found them during a further three years of piloting.

DIFFERENCE IN MACHINES

I have flown many different types of aeroplanes, and considering the extraordinary variations in the types the difference in the actual piloting of any modern machine, to my mind, is remarkably small. I am of the opinion that a pilot who is thoroughly efficient with any particular type will in a very short time be master of any.

I find that on stepping out of a very fast small scout into a really big twin-engine machine the difference in the manner of piloting is very slight compared with the vast difference in the machines. Precisely the same methods are employed, the same trouble and risks are to be avoided; the chief characteristics seem to be that the smaller and faster machines are more difficult to land but are easier to handle in the air. In the case of "crashes," the larger and heavier the aeroplane the less damage there is likely to occur to the occupants, as a tremendous amount of the impact is absorbed by the machine. Very much larger and heavier machines than those at present in use might be comfortably flown single-handed, no extra effort

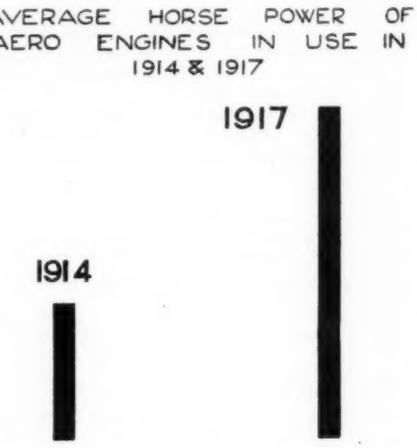


being required for the controls, provided the controlling surfaces are properly balanced.

To the lay mind it might appear that, with such contrasts in the outward appearance of the smaller and larger machines, it would be necessary to train pilots specially and extensively for each type, but in my experience this is not so. I certainly think the best results are obtained when pilots are allowed to specialize. This, however, I understand has many drawbacks on active service.

CRASHES

Crashes are mainly due to three causes, viz., engine failure, faulty piloting, and faulty machines. Engine failure undoubtedly is responsible for most of the crashes, often because of the hopeless unsuitability of the landing ground at the pilot's disposal. To many pilots engine failure is most disconcerting and it is then they are called upon to use rather more judgment and skill, so that even with a fairly suitable landing ground available they very often crash. In my experience, embracing the testing of hundreds of new machines, it is seldom that a serious defect in the engine "lets one down," it is nearly always due to a small detail. I think I have had to make more forced landings through failure of the petrol supply than all the other troubles combined. This is due more often to failure of the pressure feed than to a choke in the supply pipes and very seldom to severed connections in the feed system.



Because of the absence of a float chamber to the carburettor in the rotary engine, even a variation of the petrol pressure is more serious than in the rigid stationary type. In the former case the amount of petrol that gets to the motor is controlled by the pressure and a fine adjustment. If the pressure increases unduly the motor chokes from over-richness of mixture; on the other hand, if the pressure drops away the mixture is unduly weakened. This variation can be controlled by the fine adjustment to a large extent; but when that limit is exceeded the engine will fail. Most of the trouble seems to be caused by failure of the pump, which in some cases forms an integral part of and is driven by the motor; in others it is a separate unit, driven by a small airscrew. These failures are usually through valves sticking up and pistons becoming dry. Other causes of failure are in the relief valve not being pressure tight or sticking down. At any rate the present system of pressure feed, to my mind, is such a bugbear that it is high time something was substituted.

As far as the non-rotary motor is concerned, to my knowledge this matter is being tackled. I have been flying recently a machine fitted with a petrol pump in place of the air pressure pump, the petrol being pumped direct from the main tank to the carburettors and the surplus is returned to the tank through an adjustable spring-loaded relief valve, so that petrol is delivered at any desired pressure to the engine. So far it has proved most satisfactory, with the advantage that a punctured tank does not put it out of action. Dirt in the petrol tank accounts for quite a large proportion of engine failure in new machines. This form of trouble ought to be avoided. It is an important matter which manufacturers should be made to recognize and a very thorough system of tank washing employed before installation in the machines.

The dirt in the tank usually takes some time to work its way into and accumulate in the feed pipes or filters sufficiently to choke them. The machines are often by that time being delivered by air by pilots who are none too familiar with them, consequently engine failure means a good chance of crashing.

I remember having four forced landings while delivering a new B. E. 2 C. from Farnborough to Dover on this account. Another simple cause of engine failure which might easily be guarded against is that petrol

*An abstract from a paper delivered before the Aeronautical Society of Great Britain. From the *Aeronautic Journal*.

cocks in many cases have no definite locking device to ensure that they remain in the open position during flight, consequently they are liable to vibrate into the "off" position, thus cutting off suddenly the petrol supply. Many instances have come to my notice where petrol cocks are fitted in such a manner that the tendency is, through the weight of the cock lever, to fall shut instead of the reverse. This is such a simple and yet such an important point that it really is surprising mistakes like this are continually allowed to be made. I have had engines cut out suddenly on three occasions during the past two months from this cause alone, one meant a forced landing because the petrol cock was not accessible to the pilot, the other two were opened again in the air. It often leads to serious results as the petrol fails suddenly and it is seldom that the cause is discovered before the forced landing is made. Having somewhat a limited time at my disposal this evening I will not touch on what I have found to be other causes of engine failures, but I can assure you that as far as my experience shows they are a small proportion compared with those due to petrol supply, and improvements in this direction will reduce engine failures enormously.

Errors of judgment or faulty piloting account for nearly or perhaps as many crashes as engine failure.

The most common error made, even by experienced pilots, is losing flying speed on a turn, which starts a side slip, and given sufficient height, terminates in a nose dive, or the more serious predicament, a spin. This mistake is often made under the stress of circumstances when engine failure calls forth extra effort on the part of the pilot to reach a certain landing spot. The trouble is nearly always incurred by turning too flatly until the wing drops and the machine side slips, generally in the effort to get into more suitable ground than that available straight ahead. This is always a dangerous manœuvre and in nine cases out of ten when smashes have resulted probably less damage would have been caused had the pilot kept his machine from turning and pancaked straight ahead. I have found that most of the later type machines can be stalled (*i. e.*, speed reduced well below flying speed) without any risk of side slipping, provided they are kept in a straight course and laterally level, as they will automatically drop the nose as soon as the speed becomes so low that the elevators have little or no effect. Most of the serious accidents start at a height insufficient for the machine to get out of its side slip before striking the ground. Others strike the ground at the later stage, usually a nose dive, but in some cases a spin. If sufficient height remains after the machine assumes a nose dive there is no reason why it should not be pulled out and a normal glide resumed; but in the other event, although it is possible to get out of a spin, it is far more difficult a proposition than the instinctive manœuvre of pulling up out of a nose dive.

A spin is the extraordinary turning movement that some machines only too readily take up after being stalled on a turn or being turned too flatly even with plenty of flying speed. This is due to the machine suddenly meeting the air a great deal out of the parallel with its longitudinal axis either through side slipping, skidding, or yawing in the air. Having had more than one involuntary spin, but having been fortunate enough to have sufficient height to get out again, I feel the matter is not to be treated too lightly. The position a machine assumes in a spin is a rapidly revolving side slip or a fairly steep spiral dive, with this rather serious drawback that the more one tries to pull it up by means of the elevator the faster it spins. No matter how high one is, if one persists in trying to pull it out in a normal way, it will remain out of control because the elevator has now become the rudder, and instead of pulling it out, increases the speed of turning. If the controls are abandoned the machine will come out of its own accord, but personally I have always found the best and quickest remedy for spins is to straighten the rudder and shove the joystick forward; a clean nose dive will then result out of which the machine can be pulled.

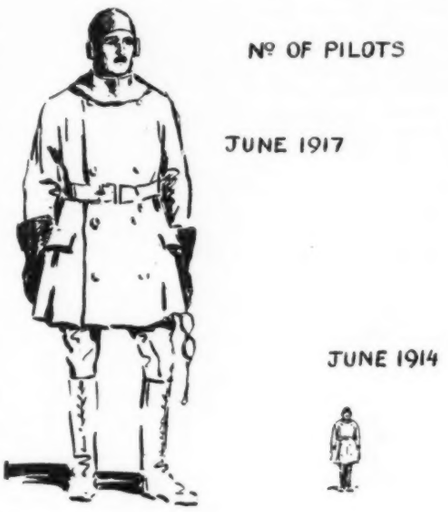
I think in the matter of spins, prevention is better than cure, and it is up to the designers to see that their machine is of the non-spinning type, as however clever and quick the pilot may be in applying his pet remedy, he may not have height enough to do so, and the results are usually disastrous.

The errors in judgment which are made in landing account for crashes galore, but these fortunately are usually a small matter compared to those mistakes made in the air, seldom resulting in more than a smashed landing chassis. Flying experience is the only remedy for this particular fault.

Landing with the wind will sometimes end in a crash through the machine over-running the limit of the landing ground; whilst landing side to wind will buckle wheels and wreck chassis. Neither of these troubles is always the direct fault of the pilot.

An easily distinguishable standard type wind-vane on every recognized landing ground would considerably lessen crashes from these causes.

Accidents directly due to faulty construction of the



aeroplane are fortunately comparatively rare, as when they happen the results are so often fatal. They occur, however, even on standard types. In some cases the aeroplane is not entirely at fault, as in these days of heavy high speed efficient machines with so little head resistance and which attain colossal speeds on diving, it is such an easy matter for the pilot to increase the load beyond the highest factors of safety. One has only to consider the load on the wings of a machine dived at 160 m.p.h. when it is pulled out with a heavy hand.

Constructional failures of machines in the air can sometimes be traced to damage inflicted by imperfect landings, usually to the back part of the fuselage in the region of the tail skid. This gets overlooked and subsequently the tail gives way under any extra stress whilst flying.

I should like here to be permitted to make a suggestion, that a detailed record be kept of every engine failure, forced landing or accident of every kind and description that happens, at any rate, at all home stations. These records to be collected and classified so that valuable data may always be available. However, some such system as this may already be in operation.

Operating Cost of Highways

By A. N. Johnson

It is generally conceded that money spent on highway construction is an investment. As such then, it should be subjected to an analysis of all the elements of cost that it may be possible to undertake. It is obvious that the first cost of construction enters into such a calculation and has long been recognized; in fact, it has frequently been the only factor that has been taken into account. Within a comparatively few years the public has come to recognize that upkeep must be considered and that it should influence the extent and character of a given improvement.

There is still a third element which has not been considered specifically in analyzing the cost of a highway. If it were a railroad, it would be classed as operating cost. The operating costs of a highway, while they have not been definitely estimated, have been in some measure recognized; as for example—it has long been the practice to reduce steep grades to such gradients as would make team hauling reasonably comfortable. But no close analysis has been made so as to determine with some exactness how much should be expended in such portion of the work.

With the introduction of motor truck traffic, and the importance that this traffic is going to play in highway economy, we now have before us readily appreciable operating costs. A simple example will make this point clearer—suppose a section of highway under consideration carries, or is estimated to carry 1,000 vehicles a day, the gross weight of which averages three tons each, and that this is the average traffic for 300 days during the year; or a total tonnage 900,000 tons.

Let us examine the effect of hauling this load over one per cent. of grade for one mile. If due allowance is made for the average efficiency of motor vehicle engines, it may be readily computed that there will be required about 4,000 gallons of gasoline to produce the necessary energy, or an approximate cost of $1,000. That is, the lessening of a gradient on a mile of road by one per cent. reduces the operating cost by $1,000 per year with the amount of tonnage as assumed. The figure 4,000 gallons is based on the assumption that 25 per cent. of the energy of the gasoline is effective in overcoming tractive resistance, and that the gasoline is 58 degrees Baume, 124,420 B. t. u. per gallon.

If it were a maintenance charge, this would be considered very heavy, or to look at it from another angle, capitalized at 5 per cent., there would be warranted an expenditure of $20,000 to reduce a mile of grades by one per cent.

To determine when a given grade should be reduced by one per cent. brings into the problem many more factors than we have sufficient data at present for an exact solution. For example, it is probably true that a certain series of grades may be so arranged that, due to the length of the road on a down grade, there would be an amount of gasoline saved that would compensate for the extra gasoline consumed on the up grade, but if the amount necessary to consume on the up grade was more than could be saved in the distance traveled on down grade, then there should be a reduction of the grade made. The amount to be justified for this expenditure would be determined primarily by the amount of traffic anticipated over the road.

There is another most important factor that must be considered in ascertaining the operating cost over a highway. This factor is the relative resistance different pavement surfaces offer to tractive effort.

Recent tests made in California by the Division of Agricultural Engineering in the University of California, and published by the Good Roads Bureau of the California State Automobile Association, furnish the basis for some very interesting study. The result of these tests was given in pounds tractive effort required per ton load over a number of different types of road surface. The least tractive effort was recorded over a plain concrete road surface, where 27.6 pounds was required to pull one ton.

As an example, in applying the relative tractive force required over different surface conditions to operative costs, let us compare a concrete and macadam surface. Over the former, as stated, the tractive force per ton was found to be 27.6 pounds; over the macadam surface, in good condition, it was found to be 64.3 pounds, or a difference of 36.7 pounds per ton load.

The tractive force required to move a one-ton load up one per cent. grade is 20 pounds, this effort being required in addition to what other frictional resistance, due to the surface of the road, it may be necessary to exert. If we interpret the additional tractive force over the macadam surface as compared with the concrete surface in terms of increased grade, it is seen that it is the same as increasing the grade by 1.8 per cent.

If the same tonnage as assumed before in the increase of one per cent. grade is taken to be the load over the road, the extra amount of gasoline that will be required to move this tonnage over the macadam surface, as compared with concrete surface, is, therefore, 4,000 times 1.8 or 7,200 gallons of gasoline per mile. That is, the operating costs for this amount of traffic over a concrete surface is, assuming gasoline worth 25 cents per gallon, $1,800.00 less per mile than over a good macadam surface; or there would be justified, capitalizing this at 5 per cent., an expenditure of $36,000 more per mile to substitute the concrete surface for macadam surface, in the event that any such additional amount were necessary for this purpose.

If the tonnage over a given highway is estimated at less, then the difference would not be as great, but whatever it may be, it is evident that it is an essential factor to be taken into consideration before the practical value of the use of any given type of surface can be ascertained.

To be sure, this operating cost is not paid out of public funds, but it is nevertheless paid by the public who uses the road, and it is as essential that it be considered in the economy of the highway as the first cost of construction or the maintenance cost.

The operating cost over thousands of miles of our highways today, if it could be ascertained, would be found to be millions of dollars more than would be the case had the roads been carefully designed and due consideration given to proper grade surface.—*The Concrete Highway Magazine.*

Ferro-Concrete Ships—I*

A Review of Some of the Technical Features of Construction

By T. J. Gueritte, Ing.E.C.P., M.Soc.Ing.Civ. (France), Councillor of the French Board of Trade

To judge by the surprise evinced in the daily papers when the first reports were published a few months ago of the great impetus given by the war to ferro-concrete shipbuilding activities, one might have imagined that there was something startlingly new in the idea, and much nonsense was printed at the time, under big headlines. And still the last few years have merely seen the development of activities dating from many years back. It is, in fact, a curious coincidence that it was the author's privilege to deliver a paper entitled "Ferro-Concrete as applied to Floating Structures" in the year 1908 before one of the Newcastle building trades associations, the matter of which formed the basis of many of the articles which were published on the subject during the last few months. The conclusions of that paper ran as follows: "The particulars and illustrations given seem sufficient to indicate that ferro-concrete has to be taken into account as a shipbuilding material, owing to its small initial cost and the absence of upkeep. The author is far from thinking that super-dreadnoughts are likely to be built in ferro-concrete, at any rate for the present; but in smaller and commercial craft and for special purposes, he is convinced that it will be used more and more. The question of weight is not so paramount as it may seem at first when to the weight of the hull is added that of all fittings and cargo, which remain the same both for ferro-concrete and for steel ships." The recent strides made in this mode of construction seem to justify those prognostics.

So much has been written lately on the general principles and history of ferro-concrete as applied to shipbuilding that it seems unnecessary to recite once more these facts, and it is proposed therefore to enter at once into more precise details.

I.—MATERIAL OF CONSTRUCTION

This is evidently a fundamental question, and we shall consider in turn the two components of a ferro-concrete hull, *viz.*, concrete and steel.

(*a*) The concrete employed must be non-porous, so as to prevent leaking and the steel being attacked by sea water; it must also be strong, so as to resist the heavy compressive stresses to which, in parts, it is submitted, and it should be as light as possible. The last-named condition is unfortunately difficult to fulfill at the same time as the other two, and the latter are of greater importance. Light aggregates such as pumice stone, ashes, coke, breeze, which are used in land work for making light concrete, are too porous; they would absorb a large weight of water and would give too weak a concrete; they cannot be utilized for ships. Clean shingle, of a flinty nature, is a suitable material, and would give a concrete slightly lighter in weight than crushed granite or whinstone. Gravel originating from sandstone must be subject to careful scrutiny before being allowed for ship construction, as it is sometimes of a somewhat porous and friable nature and might prove a source of weakness both as regards porosity and crushing strength. Crushed granite, and, generally speaking, crushed stone of a hard and impervious nature, are perhaps to be given the preference, notwithstanding their somewhat heavier weight. The same physical qualities are essential for the sand. Of the cement itself, little need be said, years of experience have proved that if it is up to British Standard Specification it will prove suitable for sea work.

With such constituents and it being understood that fresh water only should be used both for making the concrete and washing the aggregate if necessary, a suitable concrete will be made if proper proportions are adopted and the materials are properly mixed. In determining proportions great care should be taken that the aggregate be properly graded—that is, it should contain stones of various sizes, the smaller ones helping to fill the voids between the larger—and the same applies to the sand, which should be a mixture of sharp particles and of finer sand going down almost to dust. The proportions of voids both in the aggregate and in the sand should be carefully determined, and there should be a good excess of cement paste over the quantity strictly required to fill the voids in the sand, and similarly a good excess of mortar (*i. e.*, sand and cement paste) over that required to fill the voids in the aggregate. As previously mentioned, crushed stone will be used often as an aggregate, and it so happens that it contains as a rule a considerably greater proportion of voids than shingle, and this may result in porousness in the concrete unless proper attention is paid. This question of voids and of porousness is of very great importance, but forms in itself a vast subject. The author had the opportunity of reading a paper quite recently before the Society of Engineers on this subject, to which he would refer those interested; but it appears to him that its importance is such that it should be particularly emphasized tonight when dealing with concrete for ship construction.

From practical considerations the author does not deem it advisable to allow for a lesser thickness of concrete than 3 inches for the sides and bottom of a vessel, except in special circumstances, and however much one might like to see it reduced so as to lighten the structure. The figure of 2.8 inches is mentioned as a minimum in the preliminary rules for ferro-concrete ships issued by the Danish Government, but except for very small craft 3 inches will prove in practice to be the minimum. The scantlings of frames, stringers, etc., are also reduced as much as possible owing to the same desire to reduce the weight, and the thickness may be taken at 2½ inches and even less in some cases, but great care will have to be exercised to insure proper covering of the bars by the concrete and proper bond between them. It is therefore necessary to use an aggregate of small size, which will be worked easily in so restricted a space and among a comparatively great number of steel rods. Some engineers went as far as to suggest the total abandonment of aggregate, and the replacement of concrete by a mere sand and cement mortar. But the method has been proved to be unsatisfactory in ordinary ferro-concrete work, and the same would apply to ship construction. A happy medium is to be recommended, and the author's firm have ultimately adopted the following mixture for their designs:

Aggregate, being a well-graded mixture of stones from ⅝-inch size down to ¼ inch, and free from sand, 27 cubic feet. Sand, from ⅛ inch downward, the grains being also of well-graded sizes, 13½ cubic feet. Cement, 8½ cwt. Such a concrete may be termed a 4.6:2:4 concrete. The above proportions apply as long as the percentage of voids in the aggregate does not exceed 50 per cent. If it exceeds 50 per cent. a corresponding quantity of sand and cement is added. It has been suggested by various engineers that a much poorer concrete might be used with safety, say, a 1:2:4 or 1.2:2:4 concrete, if a good rich rendering were applied later on the external surface of the sides and bottoms. But such a rendering would be extremely difficult to make properly, especially when nearing the bow and stern, and with the hard wear and tear to which ships are submitted it would soon come away in patches.

In order to obviate the difficulty of making a proper rendering other engineers have suggested to use a comparatively poor concrete, say, 1:2:4 or 1.2:2:4 for the inner 2 or 3 inches of the walls and bottom and to place carefully at the same time in the mould a rich mortar (one of cement and one of sand) to form the external inch. The author's experience leads him to deprecate the juxtaposition of two concretes of so different a richness in cement, and unless supervision of the most constant and strict nature is exercised during erection he doubts the efficacy of the method. All told it seems decidedly better to adopt a uniformly rich mixture, such as mentioned above, which will give a very good face to the concrete when the moulds are struck off, prove quite impervious, afford a high crushing strength, and be easily worked into the moulds.

(*b*) *Steel.*—We turn now to the other component element of the structure, *viz.*, the steel. The general tendency in ferro-concrete practice has been to utilize as reinforcing material mild steel in the form of ordinary round bars, with an ultimate tensile strength of from 28 tons to 32 tons per square inch, an elastic limit varying from 30,000 pounds to 40,000 pounds per square inch, and an elongation of at least 20 per cent. on a length of eight times the diameter. Such steel was used in the construction of most of the numerous river and canal barges and pontoons built in ferro-concrete during the last fifteen years, and it was natural to look to the same material again, when great impetus was given lately to the construction of sea craft in ferro-concrete by the difficulty of procuring all the steel plates required for commercial craft. Mild steel was therefore used and will be used in many ships notwithstanding the difficulty one meets in obtaining it at present. Shell discard steel has been put forward as a substitute, mostly with the object of avoiding the use of mild steel, seeing that it is more easily obtainable than the latter at present, but not owing to its special physical properties. For the present, apparently, Lloyd's Register are not prepared to sanction its use. One of their surveyors, Mr. Bernard J. Ives, has stated that, "As the ferro-concrete ship is only in its experimental stage and as practically no experience has been obtained so far from actual seagoing conditions, a wise precaution at the present time is to eliminate any doubtful factors, and the steel should therefore be of the quality used in ordinary shipbuilding work."

It is a question, however, whether the disadvantages attaching to the use of shell discard steel, if one looks at the question from the usual standpoint of steel ship construction, would not be more than compensated by certain advantages it would present from a ferro-concrete point of view. These advantages are somewhat similar to those attaching to the use of a special quality of steel, which the author's firm, after careful consideration of the matter during the last two years, are now specifying for ferro-concrete ship construction. It may be stated at the outset that the problems of ferro-concrete construction as applied to naval architecture are very different from its problems as applied to land work. Firstly, and for obvious reasons, it is desirable to reduce the weight of the hull, and consequently of all the scantlings as much as ever possible, consistent with good work. It becomes, therefore, of great interest to use for the reinforcement steel possessing a higher elastic limit than mild steel, the elastic limit being an all-important factor in ferro-concrete work. Not only does this obviously tend to reduce the weight of steel required and consequently the weight of the hull, but also the same cover of concrete over the reinforcing rods can be maintained while reducing the thickness of the members by the same amount as the diameters of the high elastic limit steel rods are smaller than those of the mild steel bars which would otherwise be used, thus securing an indirect but very important saving in the weight of the hull.

A second point which deserves very careful consideration is that of the transmission of the stresses in the steel from bar to bar. As is well known, in ferro-concrete construction the bars are not tied together, nor welded, nor connected by coupling boxes (except in very special circumstances). Stresses are transmitted from bar to bar through the agency of the adhesion grip of the concrete surrounding them, the bars overlapping each other. Their ends are usually fishtailed or hooked, with a view to helping further the adhesion. In ordinary ferro-concrete work the mass of concrete surrounding the rods is comparatively large, and there is ample room for overlapping of the rods and for the hooks or fishtails, so that most of the experts in ferro-concrete consider it quite unnecessary to use bars with mechanical bond. In ship construction, as has been previously stated, scantlings are reduced to a minimum, and, the bars being very much closer together, real difficulty is experienced in finding room for overlaps of the length required if ordinary round rods are used, and also for hooks, especially in longitudinal members. The problem is serious, and experiments carried out in France last year upon a river barge of 400 tons dead weight, which was purposely tested until rupture under load in the dry proved the ultimate failure to be due to the slipping of the longitudinal rods, consequent upon the insufficiency of overlapping. It must be added that the overlaps were in fact considerably shorter than sound design would have required. But the indication given must not be neglected. It therefore becomes useful for ferro-concrete ship construction to adopt bars which present a greater adhesive power than ordinary round bars. Tests have proved that certain bars are obtainable which have a grip 60 per cent. greater than that of ordinary rounds; their use will obviously reduce the amount of overlapping otherwise required. But such greater adhesion

*Paper read at the Northeast Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne, March 12, 1918. From a report in *Engineering*.

should not be obtained by the addition of sharp projections or ribs on the bars which might have a tendency to be the starting point of minute cracks in the concrete, and which, in addition, are useless from the point of view of the main stresses. In other words, the bond should be continuous, and should not entail an additional weight of steel. To sum up the question of the steel, the author has found the nearest approach to what he considers the ideal steel reinforcement for shipbuilding work in bars manufactured from mild steel in accordance with British Standard Specification for structural steel, but which, owing to their special shape and the physical treatment they receive after rolling, acquire an elastic limit of over 50,000 pounds per square inch, present a satisfactory and continuous bond without sharp indentations or projections, and remain capable of cold bending round a bar of 1½ times their diameter without injury.

Shell discard steel, if of a somewhat unequal quality, possesses at least one of the desiderata, *viz.*, high elastic limit. Dangerous as may be its use in the shape of girders, or, more generally, structural steelwork, where stresses may be said to be extremely localized, it is felt that its use in the shape of numerous rods of small diameter scattered throughout the mass of a ferro-concrete structure does not present the same danger. It seems, therefore, that the question of its employment might be left open for further consideration, and the experience gained from the behavior of the numerous ferro-concrete works in which it was used since 1915 will be of great help in that direction.

II.—SYSTEMS OF CONSTRUCTION

Having examined the constituting materials, one may now attempt to reply to the query: "What are the various systems of construction?" They seem to fall under two headings—Plastered ships; moulded ships.

(*a*) *Plastered Ships.*—The first cost of a mould in which to cast a ferro-concrete ship, in a similar way as is generally done for ordinary ferro-concrete work, is high, and it was natural that one should attempt to avoid using one. Many of the numerous river barges and pontoons built in Italy since 1902 consisted mostly of a steel mesh work set to shape and plastered on both sides with cement mortar, very much as a ceiling of a room is plastered on a metallic lathing. Italians are very clever cement plasterers, and the method proved successful for small craft which are never strained heavily. Small motor boats or canoes have been built similarly in various countries, including, of course, the small pioneer rowing boat built in France in 1849 by Lamjot, and which has now become historical. When one comes, however, to heavier craft, and particularly seagoing craft, mesh work is found to be not practical for the arrangement of the main steel reinforcement; the number of skilled plasterers able to do justice to such difficult work is very small at present; and what is more important, plaster work of that kind does not give a concrete sufficiently strong to meet the stresses imposed upon it. The claims of the "cement gun" in that respect do not appear as yet to be justified. The author is convinced that for all vessels of large size the plastering method has to give way to the method of moulding and casting, and he is under the impression that it will not be sanctioned by at least one of the Registry Societies, in view of experience lately acquired in that direction.

(*b*) *Moulded Ships.*—(1) In the first place, there should be a warning against the practice recommended by one or two American contractors of building a sort of rigid metallic work—lattice girders forming the skeleton of all the frames, and also the skeleton of the sides, and encasing this metallic framework in concrete. The advantages claimed are simplicity and quickness of construction. It must be stated that analogous practice prevailed among a few designers in the early days of reinforced concrete construction, but it was gradually discarded in favor of the more scientific and efficient designs which have been in universal use for the last twenty years, the principle of which is that the reinforcement is not a rigid frame by itself. The author considers that there would be no appreciable saving in time, and there are very serious defects inherent to the system. All ferro-concrete experts agree that the ideal design in ferro-concrete is that in which the reinforcing rods are individually as small as possible and as numerous as is practicable, so that the stresses be distributed to the extreme possible limit throughout the mass of ferro-concrete. The result is best attained by the use of small rods and links. It has been very properly stated by the most eminent authorities on ferro-concrete that it is a new material and not a mere juxtaposition of concrete and steel: it has, in fact, qualities and idiosyncracies of its own quite distinct from those of its constituent elements. If, however, the steel is concentrated in parts of the mass instead of being distributed throughout, the work thus obtained loses those peculiarities just referred to; the concrete will not lend its properties to the steel and borrow some from the latter in so complete a manner, and *vice versa*. In particular, the large cracks so characteristic of ordinary concrete work, and unknown in ferro-concrete, would tend to appear, and this would be a very serious defect in ships. The work would also lose the resilience and elasticity which is so striking a character of ferro-concrete. Another point is that a rigid framework of that kind, instead of being made of round bars, would require flat bars and small angles; in fact, structural steelwork of the very kind that is most in demand today. It would also require the employment of steelworkers of the very kind one wishes at the present time not to draw upon, seeing that all the steel work would have to be punched, bolted and riveted. Moreover, experience has shown that such a method of reinforcement is more wasteful in steel by 15 per cent. to 20 per cent. It has also been found in practice that in reinforced concrete work it is most advisable to avoid any sharp angles or corners in the steelwork, all such angles being potential starting points of cracks; and that concrete adheres less easily to comparatively large and flat surfaces such as presented by angle bars than to ordinary round bars. It may also be added that if, in order to avoid riveting, an attempt is made to use bolts, as the bolt holes will be greater diameter than the holes (so as to facilitate fitting up) there will remain throughout the framework an immense number of small recesses to which concrete will not have access; the steelwork will therefore not receive in those points the protection against corrosion which the concrete should afford it, and such points will be potential starting points of corrosion. For all those reasons, tempting as the idea may be at first to those not thoroughly accustomed to reinforced concrete work, rigid framing has to give way to the usual non-rigid round bar skeleton reinforcement.

(2) The Norwegian method of casting the boats upside down, launching them in that position, and letting the hull right itself in the water, has been profusely described and illustrated in the daily papers and magazines. The reason for that unusual procedure is stated to be a desire to avoid the use of double shuttering. But, as far as the deck and bottom are concerned, there is no more need for a double shuttering in the usual method than in the upside-down one, and as regards the sides there is as much need for it in one as in the other. It seems that the upside-down method has been used for very small vessels, 200 tons deadweight, but it is doubtful whether it is workable in the case of bigger craft, say, 1,000-ton or 2,000-ton boats, and the author is at a loss to see any advantages in it.

(3) In the construction of river barges in France, the desire to reduce the cost of shuttering has led to certain constructors experimenting with pre-cast wall plates of the required dimensions to fill the rectangular spaces between frames and stringers. The frames and stringers are cast *in situ*, and the wall plates set in position between them so as to be incorporated into the structure during their concreting, the bond being given by the ends of the reinforcing bars of the plates, which protrude all round. Although the results were said to be satisfactory (at first in any case) it is interesting to note that when the same contractors built larger river craft (600 tons and 1,000 tons deadweight) they abandoned the slab principle and reverted to casting *in situ*. For seagoing craft, which are submitted to hogging and sagging stresses, the author feels that the slabs would work loose, and further, the steel used in their construction, and which is in short lengths, would not be utilized for meeting the general stresses in such an efficient manner as it can be when the plates are monolithic with the frames and stringers. This mode of construction is therefore to be deprecated.

(4) Another "system" is that in which timber moulds are dispensed with for the walls by using two sheets of metal lathing between which the concrete is poured. Some of it works through the mesh and forms knobs upon the two outer surfaces, which knobs in turn form anchorage for plastering coats added later on. The objection against the use of plastering coats required to finish the surface has been stated before. Another drawback of this method is that concrete poured between two resilient sheets of meshing cannot be rammed or punned properly, and, in consequence, it is impossible to obtain a good, strong and impervious concrete. The advocates of this method, in fact, are said to recommend the addition of a waterproof coating, which the author has no doubt would indeed prove very necessary with such a method.

(5) Reverting now to the normal and usual method of construction, it can hardly be divided into systems. A few patents have been taken in the matter, but they mostly bear on questions of detail; the general principles underlying all the designs are the same, and it is merely the experience and skill of designers which may differentiate the various types adopted. In that respect the author is fully in accord with the remarks made by Mr. A. T. Wall in the *Engineering Supplement* of *The Times* regarding the absolute necessity for close cooperation in the design of ships between naval architects and ferro-concrete experts. The latter, or at any rate the broad-minded ones among them, fully recognize that the science of naval architecture and the practical experience which is necessary when applying its principles, require years to be acquired; and in the same way the extremely complex problems of ferro-concrete design as applied to naval architecture can only be solved by the application of years of experience. Excellent results will be the fruit of close cooperation, and the attempt to work independently of each other has already resulted in a number of failures, and will continue to do so.

Having thus reviewed the material and the method of construction of ferro-concrete ships, it is now necessary to inquire into the claims put forward by the advocates of such ships, and see whether they can be substantiated.

III.—SPEED OF CONSTRUCTION

One of these claims is a great speed of construction. It must be borne in mind that up to the time of writing the biggest units launched are barges of 1,000 tons deadweight. For bigger tonnage no actual facts can be mentioned, but by inference experts may gauge pretty accurately the time required.

In the construction of a large number of 250-horsepower tugs now being built in France, the author was able to satisfy himself that two weeks were sufficient to erect the moulds (for repeat tugs; the erection of the first mould took somewhat longer) and place the steel in position. The process of concreting was occasionally carried out in 48 hours. All told, it is safe to say that in normal working the yard referred to completes a hull in three weeks. The tugs take water broadside on, and an average of three weeks is allowed for maturing. With the restricted amount of labor at present available, the said yard can turn out one of these tugs every week, but from explanations given to the author by the yard's manager it is certain that two tugs could be completed every week in normal times. In another place the author has seen in what was four months before a bare field, two 1,000-ton deadweight barges ready for launching, and several others following closely. Barges of that kind, or again, the hulls of small cargo steamers of 1,000 tons deadweight, may easily be turned out and launched at the rate of one every ten weeks from each slip in a well-organized yard. For obvious reasons it is impossible at the present time to give precise figures as to the actual speed of construction of bigger ferro-concrete craft. However, having discussed the programs of construction both with British and with French contractors, the author considers that in regular working order the completion of the hull of 1,000 tons deadweight cargoes would take about 1½ months from start to finish. That of 2,000 tons 2 months. A 3,000 tons cargo would require 2¾ months, and a 5,000 tons about 4½ months. The time required for the fitting of machinery, etc., would be practically identical for such ships and for steel ships, so that from the above figures the total time required to complete the ship may be deduced. It will be understood that from 3 to 5 weeks has to be added to allow for the maturing of the concrete. In ordinary land work one considers generally that a test load may be imposed upon a new floor 5 or 6 weeks after its completion. But the concrete used in that case is not so rich in cement as for ships, and the richer the concrete the quicker the required strength is attained. It might be possible to utilize that period for partly fitting up the ship instead of waiting until she is afloat, so that the maturing period would not be lost altogether.

[TO BE CONTINUED]

Quantity of Alcohol Obtainable from Various Materials

FOR a crop of 8 tons per acre the yield of alcohol obtainable per acre would be 100 gallons for sweet sorghum, 144 gallons for sugar beet, 160 for potatoes; 176 for artichokes, 280 for sweet potatoes, and 312 gallons for cassava. In order to obtain a yield of 100 gallons of spirit from 1 acre, the crop of sorghum grain would have to be approximately 1¼ tons per acre: maize, about 1⅓ tons; barley, nearly 1⅓ tons; cassava, 2⅔ tons; sweet potatoes, nearly 3 tons; artichokes, 4⅔ tons; potatoes, 5; sugar beet, 5⅓; and of green sorghum, 8.

Acid Resisting Iron

In a paper read before the London Section of the Society of Chemical Industry, Mr. Sydney J. Tungay discussed the developments in the manufacture of acid resisting iron, especially for chemical plant. For many years chemists and metallurgists had been seeking some form of metal which could be adapted for the requirements of the chemical industry, for the purpose of resisting the corrosive action of acids, but it was only in comparatively recent years that developments had been made which rendered available acid resisting iron suitable for large chemical plants. It had long since been proved in the laboratory that a pure form of iron could be rendered resistant to either sulphuric or nitric acid by the addition of a suitable proportion of silicon, chromium or other elements, but the development and application of such metals upon an industrial and commercial basis was not approached until some twenty years ago.

In Paris, Jouvre successfully made small castings, and in Germany "neutraleisen," so-called, was produced by more than one metallurgical house for producing castings to withstand nitric or sulphuric acids, but the firms who took it up did not meet with commercial success. In more recent years the development of the electric furnace had proved a valuable aid in the satisfactory commercial production of such alloys as ferro-silicon and ferro-chromium. Kowalke, in America, had made considerable research, and his tests showed that silicon present in a lesser quantity than 12 per cent did not promote satisfactory resistance to corrosion, whilst, when it reached 19 per cent or more, the acid resisting quality of the alloy again fell.

In addition to the difficulties presented by the serious shrinkage of non-corrosive iron castings during cooling, which amounts to slightly over ¼ inch per foot in each direction, as compared with a shrinkage of about 3-32 inch per foot in the case of ordinary cast iron, the presence of graphite in any considerable quantity caused disaster. The iron must also be low in carbon and phosphorus, otherwise, during the process of cooling, these compounds tended to separate out and form eutectics. Some tests recently made at the Manchester School of Technology showed these eutectics to consist largely of phosphorus and silicon. These difficulties, however, had been largely overcome by suitable furnaces and by improved manipulation in mixing the metal, with the result that in present commercial practice it was found quite possible to produce a satisfactory acid resisting iron, but its application to the manufacture of large plant for the chemical industry had not until recently been completely successful.

The following were the physical constants of acid resisting iron, as compared with cast iron:

	Cast iron	Acid resisting iron
Density	7.3	6.8
Tensile strength (tons per square inch)	9–10	6–7
Melting point	1150 deg. Cent.	1200 deg. Cent.
Hardness	24	35
Heat conductivity	10	8
Electrical resistance	8	10
Contraction per foot in casting	3-32 in.	9-32 in.
Crushing lin. cubes	40 tons	34 tons

Since the outbreak of war, acid resisting iron had played no small part in the construction of plant for the production of propellants and high explosives. For the condensation of nitric acid it was found to be a great boon, as plants of large capacity had to be erected rapidly at short notice, and it was found possible to install many large nitric acid plants of this class of iron much more rapidly than would have been the case with pottery, as was more usual. In addition, it was found that acid resisting iron possessed a much higher efficiency owing to its greater heat conductivity than earthenware. The heat transmitting power of acid resisting iron had been calculated at ten times that of stoneware or quartz, and thus the parts could be made much smaller. A condenser built of acid resisting iron condensed a charge of nitric acid in sixteen hours, as against thirty-six hours with a similar condenser built of pottery. The metal was now being used in other directions, including the concentration of sulphuric and other acids.

With all this success there were still difficulties to be overcome. All alloys of low silicon content, say, 10 per cent, were attacked very readily by the acids mentioned, and while acid resisting iron which contained from 16 to 18 per cent was satisfactory from the resistance to acid point of view, it was so very hard that it was impossible to machine it in any other way than by grinding with high-speed abrasives.

Apart from chemical plant, this iron had a wide application for anodes in connection with electro-metallurgical processes. On the outbreak of the war it was impossible to obtain magnetite anodes, since these were chiefly made in Germany, and a substitute was found in acid resisting iron. Whilst the material was not absolutely unacted upon when used for this purpose in copper sulphate solution, many times its original weight of copper could be deposited before the anode showed any serious signs of corrosion. The mechanical strength was a further considerable advantage, although a little higher electrical energy was required than with anodes made of magnetite.

Captain Goodwin said the development of acid resisting iron had been most unscientific. When it was first started it was done in a most haphazard way, and scientific control had been very largely absent. The necessities of the war had altered matters somewhat, because manufacturers found it paid them to erect new plant. There was, however, a curious difference in the various makes of iron of this class. In the United States the silicon content was about 15 per cent, yet other manufacturers had 0.3 per cent, and another 2½ per cent of manganese, and it would seem that better results would have been obtained if some of the manufacturers had employed chemists to advise them. Past results had largely been obtained by methods of trial and error. There had been great difficulty in dealing with hydrochloric acid, and, so far as he was aware, only one alloy had been evolved which would stand that, and the silicon content in that case was from 16 to 20 per cent, to which was added a small percentage of an uncommon metal, the name of which he was not at liberty to mention. Another curious point was that the skin of these castings was different from the inside, and it was evident that further research was required. He suggested that manufacturers would do very much better if they pooled their interests and spent money on research.

Mr. J. W. Hinchley thought the paper indicated the necessity for some chemical engineering education in this country. The properties of acid resisting iron were not, in his opinion, at all appreciated yet, and he agreed with the previous speaker as to the need for greater research. There were some obvious faults in the comparison of physical constants given in the paper. The figures for heat conductivity and electrical resistance were incorrect. It was necessary to have the iron as free as possible from graphite, and for that purpose it was necessary to use an electric furnace. On the other hand, he did not think the question of machining the material was as hopeless as it might appear. It was possible with some brands, which had good acid resistance, to do some fairly satisfactory drilling and machining if the tools were properly chosen in the first instance. At the same time credit was due to the manufacturer, notwithstanding his unscientific methods, for having carried the manufacture of this metal a stage further.

Mr. Bannister said a primary cause of failure in these metals was porosity, although sometimes this porosity was quite minute, and only discernible under microscopic examination. Another important point was the amount and nature of the graphite present. He did not think the material would ever be got quite free of graphite, but the object in view should be to have it in a finely divided state, and evenly distributed throughout the casting. He had found castings behave perfectly well, varying considerably in manganese, from below 0.5 per cent to 2 per cent.

Mr. Walter Reid thought that if the metal was subjected after casting to the heat treatment, that had been found so useful in steel, it could be made very much tougher and able to withstand shocks better than it did now.—*The Practical Engineer.*

Permanent Periodicity in Sun-Spots

A re-examination of the available sun-spot records for the 160 years from 1750 to 1910, leads to the conclusion than an unbroken solar periodicity of about 11.125 years is firmly established, if the two strongly discrepant cycles from 1776 to 1798 are left out of consideration. The graph of this periodic constituent is shown to have the property of being anti-symmetrical with respect to the axis which bisects its undulations, each undulation giving equal areas above and below, the curve repeating as a reflected image. Examination of the residuals after extraction of the 11.125-year pulses shows no indication of periods other than are sporadic in character. A letter is appended from Wolfer, of Zurich, giving interesting particulars concerning the compilation of the sun-spot data, those of the discrepant period from 1775 to 1795 being almost exclusively made by Stoudacher of Nuremberg. The epoch of maxima 1778 and 1787 are considered fairly reliable, and the large departures of the lengths of the periods observed between 1770 and 1805 from the mean value of 11.125 years are to be considered as real.—Note from *Science Abstracts* on an article by J. Larmor and N. Yamaga in *Roy. Soc. Proc.*

War Work of a Contributor

Our readers may be pleased to know that Dr. R. W. Shufeldt, who is writing the popular series of papers on "Anomalies of the Animal World," which are appearing in the Supplement, and who has contributed many other valuable articles on natural history to our columns, is now actively engaged in war work in Washington. He is in charge of the collections of the museum of the surgeon-general's office, which has for its object the collecting, preserving and exhibiting material illustrative of military medicine and surgery, material and appliances relating to army hygiene and public sanitation, matter illustrative of the advance of medical and surgical knowledge and of interest and value to the history of the medical department of the army. It is a most comprehensive undertaking, which Dr. Shufeldt's wide scientific qualifications fully fit him to carry out, and it is from this material that the medical history of the war, as represented by our armies, will be written.

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